Volume 1

582

Oak Ridge
RESERVATION

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Abstract: The purpose of this report is to provide information to the public about the impact of the US DOE facilities on ORR. The document describes the environmental surveillance and monitoring activities conducted around ORR. The report summarizes all information and data collected during 1990 regarding effluent monitoring, environmental surveillance, and estimates of radiation and chemical dose to the surrounding population.
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OAK RIDGE RESERVATION ENVIRONMENTAL REPORT FOR 1990

VOLUME 1: NARRATIVE, SUMMARY, AND CONCLUSIONS

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EXECUTIVE SUMMARY

The *Oak Ridge Reservation Environmental Report for 1990* is the 20th in a series that began in 1971. It documents the results of a comprehensive program to estimate the impact of the Department of Energy (DOE) operations in Oak Ridge upon human health and the environment. The report is organized into ten sections that address various aspects of effluent monitoring, environmental surveillance, dose assessment, waste management, and quality assurance. A compliance summary is also incuded that gives a synopsis of the status of each facility relative to applicable state and federal regulations.

Data are included for the

- **Oak Ridge Y-12 Plant,** which fabricates nuclear weapon components and conducts research and development (R&D) activities in support of that national defense mission;
- **Oak Ridge National Laboratory** (ORNL), a multipurpose center for R&D in the biomedical, environmental, and physical sciences; nuclear and engineering technologies; and advanced energy systems; and the
- **Oak Ridge K-25 Site,** where production operations in uranium enrichment have ceased, but active R&D and waste storage activities continue.

Volume 1 presents narratives, summaries, and conclusions based on environmental monitoring at the three DOE installations and in the surrounding environs during calendar year (CY) 1990. Volume 1 is intended to be a "stand-alone" report about the Oak Ridge Reservation (ORR) and provides the reader an in-depth review of 1990 data. Volume 2 presents the detailed data summaries from which these conclusions have been drawn and should be used in conjunction with Vol. 1.

Scope and Purpose

The scope of this report is the ORR and the three facilities that are managed by Martin Marietta Energy Systems for DOE. The purpose is to document effluent monitoring and environmental surveillance results and to evaluate potential exposure pathways to humans.

Effluent monitoring and environmental surveillance programs are intended to serve as effective indicators of contaminant releases and ambient contaminant concentrations that have the potential to result in adverse impacts to human health and the environment. These programs also provide data that are used to verify compliance with state and federal permits and regulations. An additional objective of these programs is to provide a standard for measuring the progress in implementing improved environmental management practices and demonstrating the efficacy of remedial actions that are designed to correct deficiencies in past practices.

The stated goal of the environmental management programs at the DOE Oak Ridge installations is to reduce environmental releases from current and past operations to levels that are demonstrably and consistently "as low as reasonably achievable." This includes efforts to develop and demonstrate more effective means to isolate and/or treat the hazardous and radioactive wastes that are inevitable by-products of nuclear and other energy-related production and research operations.

Efforts to clean up contaminated storage and disposal areas and to close disposal sites that do not meet current standards are now the focus of long-term, large-scale remedial action efforts. Likewise, new and improved treatment and isolation systems for gaseous, liquid, and solid wastes contribute annually to continuing reductions in potentially harmful emissions and effluents from current operations. This measurable evidence provides a degree of confidence and assurance that the aggressive, long-term program of corrective actions and waste management improvements now under way will be successful in restoring and enhancing environmental quality in the future and in reducing the potential for any deleterious impacts on human health or the environment from current or past Oak Ridge operations.

AIRBORNE DISCHARGES, AMBIENT AIR, AND METEOROLOGICAL MEASUREMENTS

Permitting Status

About 780 air emission sources are now permitted by the Tennessee Department of Conservation (TDC) for the three Oak Ridge installations.

Radioactive Discharges to the Atmosphere

During 1990, 102,000 Ci of radionuclides were released to the atmosphere from Oak Ridge installations. The differences from year to year can be accounted for almost totally by two inert gases, xenon and krypton. These gases have little or no interaction with the terrestrial biosphere, including humans. The total curie discharge for each of the 30 isotopes that were quantified is shown in Sect. 2.

Uranium is the primary radioactive element released from the Y-12 Plant. Uranium emissions have shown a gradual decrease in recent years at the plant. During 1990, the lowest discharge from the Y-12 Plant in the last 5 years was recorded. This reduction in 1987, 1988, 1989, and 1990 compared to 1986 was due in part to improved uranium emissions monitoring in 1987 and the installation of new exhaust gas filtration systems, especially in the depleted uranium areas of the plant.

Discharges, as well as meteorological data, are input into dose models to predict the radiation dose to the maximally exposed individual and to the population within 80 km (50 miles) of the DOE Oak Ridge facilities (see Fig. 1). The calculated 50-year committed effective dose equivalent to the maximally exposed off-site individual from airborne effluents from the entire ORR in 1990 is approximately 2 mrem, well within the federal standard of 10 mrem. The estimated collective committed effective dose equivalent to the approximately 940,000 persons living within 80 km (50 miles) of the ORR is approximately 30 person-rem for 1990 airborne emissions. This represents about 0.01% of the 2.82×10^5 person-rem that the surrounding population would receive from all sources of background radiation.

Radionuclide Concentrations in Air

Atmospheric radionuclide concentrations occurring in the general environment around the ORR, and the general region are monitored or sampled continuously by an air-monitoring network. The reservation perimeter air monitors assess the impact of the entire ORR on air quality. The remote air monitors provide information on reference concentrations of isotopes and gross parameters for the region.

Measurements were taken of air concentrations of 15 radioactivity parameters. Data analyses and summaries are presented in Sect. 2.

Analysis of the ORR perimeter air-sampling data shows that operations on the ORR are very slightly increasing local airborne concentrations of radionuclides. These range from <0.01% to 0.057% of the derived concentration guides (DCGs) for the network averages. No significant changes in the concentrations of these radionuclides were detected between 1989 and 1990 data for the remote stations. Therefore, based on these data, ORR operations are having a slight impact on local air quality and are not measurably impacting the regional air quality. The local impact is well below the DCG.

WATERBORNE DISCHARGES AND SURFACE WATER MONITORING

Each of the Oak Ridge installations has a National Pollutant Discharge Elimination System (NPDES) permit. More than 400 NPDES stations were sampled, requiring more than 65,000 water analyses. During 1990, the Y-12 Plant, with 97 noncompliances, was 98.0% in compliance with NPDES standards. ORNL had 101 noncompliances and was 98% in compliance. With 26 noncompliances, the K-25 Site was 99.9% in compliance.

The ambient surface water areas monitored by the three installations include the Tennessee and Clinch rivers, White Oak Creek, Bear Creek, East Fork Poplar Creek, and Poplar Creek, all of which could be affected by operations at the DOE installations.

Program descriptions and results are presented in Sect. 3.

Radionuclide Discharges to Surface Streams

At the Y-12 Plant, ORNL, and the K-25 Site, radiological effluents were well within limits at all effluent locations. The radioactivity discharges to surface waters, which had declined over the previous 4 years, increased in 1989, but declined again in 1990. Radionuclide discharges to surface streams are mainly emitted from ORNL to the Clinch River via White Oak Dam. Figure 2 represents the 4-year trend of maximum calculated 50-year committed effective dose equivalent from drinking water at the Gallaher Water Plant monitoring station. Factors that may be affecting the discharge of radionuclides at White Oak Dam are currently under investigation as part of the Environmental Restoration Program.

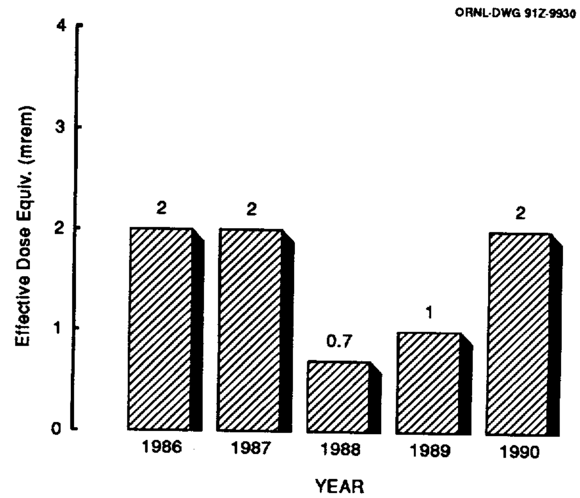

Fig. 1. Estimated maximum effective dose equivalents from airborne emissions from ORR.

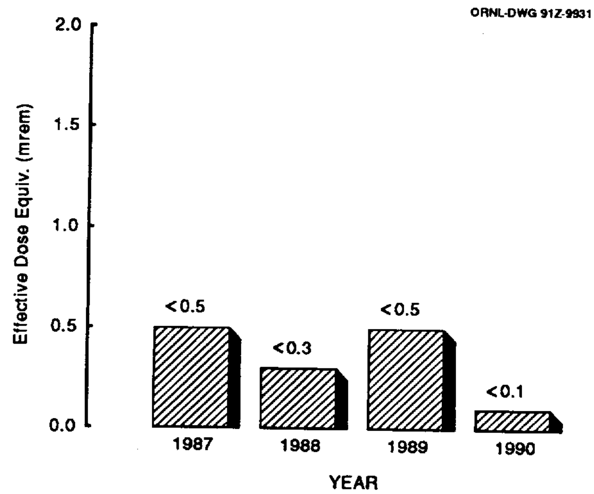

Fig. 2. Maximum calculated 50-year committed effective dose equivalent from drinking water from the Gallaher Water Plant.

GROUNDWATER

Seven land-based waste disposal sites at the Y-12 Plant are Resource Conservation and Recovery Act (RCRA) Interim Status facilities and, as such, require groundwater monitoring. Currently, groundwater monitoring at five of the sites has detected volatile organics, nitrates, heavy metals, and radioactivity at levels that exceed applicable standards. The focus of the assessment monitoring program is to gather data to define rate of migration of the contaminants, their concentration, and to better define contaminant plume boundaries. Although it is too early to determine accurately the quantitative rate and extent of migration, data indicate contamination remains relatively close to its source. For instance, at the S-3 Pond site the highest concentrations are within 150 m (500 ft) of the site; nitrate, the most widespread groundwater contaminant, has been detected in wells as far as 920 m (3000 ft) southwest. Additional wells and continued monitoring are needed to draw further conclusions.

At ORNL, about 250 known potential waste sites are grouped into 20 Waste Area Groupings (WAGs), of which at present 11 are being or are to be monitored along their boundaries for groundwater quality. Because of the large number of remedial action sites at ORNL located close to one another and the proven hydrologic interconnections between many of these units, individual monitoring and assessment was shown to be impractical. Therefore, the concept of WAGs was developed to evaluate potential sources of releases to the environment. A WAG is a group of multiple sites that are geographically contiguous and/or occur within hydrologically defined areas. It allows the establishment of a suitably comprehensive groundwater and surface water monitoring system in a far shorter time than that required to deal with every facility, site, and Solid Waste Management Unit (SWMU) individually. Some WAGs share common boundaries, but each WAG represents distinct small drainage areas within which similar contaminants may have been introduced. Monitoring data from each WAG will direct further groundwater studies aimed at addressing individual sites or units within a WAG, as well as contaminant plumes that extend beyond the perimeter of a WAG.

The K-25 Site Groundwater Protection Program currently includes 191 monitoring wells at 31 remedial action and 2 RCRA sites.

The 11 wells at the 2 K-25 RCRA sites (K-1407-B and C Ponds) continued under modified interim status detection monitoring during 1990 as approved by TDC. Wells at 26 remedial action sites, underwent one or two quarters of baseline monitoring during 1990, depending on when they were installed. Baseline monitoring involves four consecutive quarters of sampling for an extended list of constituents, including field parameters, indicator parameters, water quality parameters, volatile organics, semivolatile organics, metals, radioactivity, polychlorinated biphenyls (PCBs), pesticides, and herbicides. All new wells undergo baseline monitoring during their first year of service.

Evaluations of hydrogeologic and groundwater quality data that were conducted by the K-25 Site during 1989 led to a realization that the approach to groundwater monitoring for remedial actions required modification. Because of the potential for intermingling of groundwaters contaminated by individual sites within the same groundwater drainage basins, it became obvious that the most efficient, cost-effective, and technically defensible approach to remedial action groundwater monitoring at the K-25 Site would be to divide the plant into hydrogeologically defined WAGs. Thirteen WAGs, encompassing from 1 to more than 10 individual sites, have been identified. The K-25 Site Groundwater Protection Program completed a transition to the WAG approach for remedial action monitoring during 1990.

OTHER MONITORING

Biological Monitoring

Contaminant concentrations in fish samples during 1990 are comparable to, or are generally lower than, concentrations found in previous years. Samples were collected to measure concentrations of mercury, PCBs, ^{60}Co, ^{137}Cs, and total radioactive strontium in bluegill from the Clinch River. No guidelines exist for radionuclide concentrations in fish. However, dose calculations were based on concentrations of radionuclides in fish and assumed consumption rates. These calculations are described in Sect. 7.1 of this report. To put doses from waterborne radionuclides into perspective, a person who eats fish and drinks water from Kingston could add about 0.03% to his or her annual dose from background radiation. Figure 3 shows a 4-year trend of estimated effective dose equivalent for eating fish caught in the Clinch River near Kingston at Clinch River kilometer (CRK) 8.0.

Milk samples were collected from five locations in the 80-km area around the ORR and were analyzed for ^{131}I and total radioactive strontium. The estimated effective dose equivalent for drinking this milk averages 0.1 mrem.

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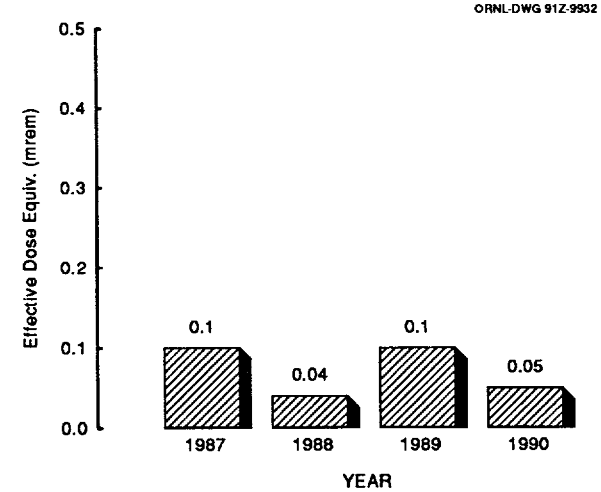

Fig. 3. Maximum calculated 50-year committed effective dose equivalent from eating fish taken from the Clinch River at CRK 8.0.

Stream Sediment Sampling

The stream-sediment-sampling program consists of six sampling locations on Poplar Creek and two locations on the Clinch River. These samples were collected in the summer and analyzed for concentrations of mercury, lead, nickel, copper, zinc, chromium, manganese, aluminum, thorium, cadmium, and total uranium.

The sampling locations are shown in Fig. 6.2 of this report. In most locations, the concentrations have been decreasing since 1985 until this year. In 1990, uranium, lead, nickel, chromium and aluminum have all increased. Samples taken on the Clinch River (SS7 and SS8) continue to have the lowest concentrations of the sampling stations.

RADIATION DOSE TO THE PUBLIC

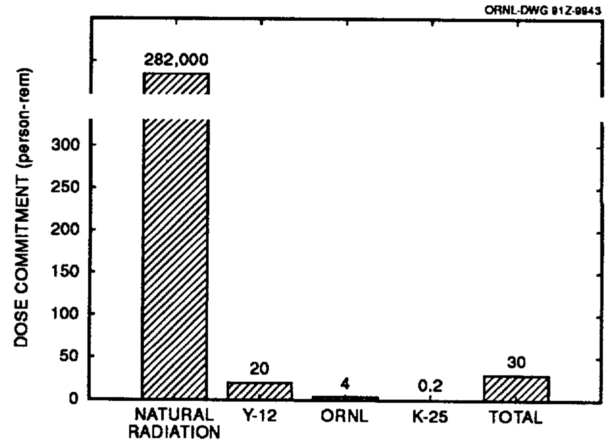

Fig. 4. The collective 50-year committed effective dose equivalent of the entire population within 80 km (50 miles) of the three installations.

The collective 50-year committed effective dose equivalent to the entire population (940,000 persons) residing within 80 km (50 miles) of the ORR during 1990 is estimated to be 30 person-rem from releases of radionuclides from the ORR to the atmosphere. This dose equivalent is about 0.01% of the collective dose equivalent to the entire population from one year of exposure to natural radiation (see Fig. 4). A fatal cancer risk from reception of such doses can be calculated using a risk factor of 0.0004 per rem of effective dose equivalent, even though there is no conclusive evidence to support the existence of a risk from reception of such a low dose at such a low dose rate (i.e., the actual risk factor could be 0). The calculated fatal cancer risk associated with the 30-person-rem effective dose equivalent is 0.01. This means that it would take, on average, 100 years of such exposures for one fatal cancer to have a chance of developing in the entire population. The chance that an individual who receives the average effective dose equivalent (0.03 mrem) might develop a fatal cancer over a lifetime is 1 in 94,000,000.

1990 COMPLIANCE SUMMARY

OAK RIDGE RESERVATION

BACKGROUND AND OVERVIEW

The ORR, including the Y-12 Plant, ORNL, and the K-25 Site, operates in conformance with requirements established by a number of federal and state statutes and regulations, Executive Orders, DOE Orders, and Compliance and Settlement Agreements. Compliance status with regard to major environmental statutes is summarized below.

The DOE Order 5400.1, "General Environmental Protection Program," defines the mandatory environmental standards in effect at DOE operations. These environmental standards fall into three categories: (1) those imposed by federal statutes, regulations, and requirements; (2) those imposed by state and local statutes, regulations, and requirements applicable to DOE; and (3) those imposed by DOE directives. This compliance summary section addresses the standards that are significant for environmental compliance.

Several federal, state, and local agencies are responsible for enforcing environmental regulations at the ORR and the component facilities. DOE itself, through directives to field offices and compliance audits, is the initiating organization. Principal among other regulating agencies are the Environmental Protection Agency (EPA) Region IV and TDC. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards as directed by statutes passed by the U.S. Congress. In some instances, EPA has delegated regulatory authority to TDC when the Tennessee program meets or exceeds EPA's requirements. Where regulatory authority is not delegated, EPA Region IV is responsible for reviewing and evaluating compliance with the EPA regulations as they pertain to the ORR.

Although progress has been made toward achieving full regulatory compliance at the ORR and each of the facilities, much remains to be done. Ongoing self assessments of compliance status and implementation of corrective actions continue to identify environmental issues. These issues are discussed openly with the regulatory agencies to ensure that compliance with all environmental regulations will be attained.

OAK RIDGE Y-12 PLANT

COMPLIANCE STATUS

Clean Air Act (CAA) and National Emission Standards for Hazardous Air Pollutants (NESHAP)

The Y-12 Plant has approximately 185 state air permits; more than 500 air emission sources are permitted by TDC. Eighty-five radiological stacks are equipped with continuous stack samplers to monitor uranium emissions. A plan for using these samplers to meet the requirements of 40 CFR Part 61 for sampling significant radionuclide emission points was prepared. This topic is discussed in more detail under Current Issues.

Current efforts are focusing on ensuring that all sources are permitted and are operating in accordance with those permits. Procedures for permitting, compliance inspection, and documentation of compliance are in place. Initial inspections of all potential air emission sources are complete. Major source areas are appropriately permitted, and documentation of compliance is being developed. A number of minor sources, most of which are exempt from permitting under State of Tennessee rules, are being addressed also.

Clean Water Act (CWA)

The Y-12 NPDES permit encompasses 240 point discharges that require compliance monitoring, resulting in 12,500 samples per year. Five major wastewater treatment plants have been constructed and brought online since 1983. NPDES excursions and spills have occurred; however, progress continues in minimizing these incidents and their effects on receiving streams. An application for renewal of the Y-12 NPDES permit was provided to TDC in November 1989. The current NPDES permit expired May 23, 1990. A new NPDES permit is expected to be negotiated with TDC in 1991. The Y-12 Plant continues to operate under the existing permit pending notification of the new permit with TDC.

Sanitary wastewater is discharged to the plant sanitary sewer system, which is connected to the city of Oak Ridge sewer collection and treatment system. Discharge is monitored in accordance with an industrial user's permit. The monitoring system has been evaluated, and upgrades to the system have been proposed. An application for renewal of this permit was filed in October 1990 under guidelines of the new Oak Ridge Industrial Pretreatment Program.

Resource Conservation and Recovery Act (RCRA)

Y-12 operates 38 interim status RCRA units; 11 of these units recently received final Part B permits (of these, 10 are under appeal). Five additional permits are in draft form, and six units have permits-by-rule in place. The balance are undergoing or are targeted for closure. More than 200 RCRA waste streams are generated at the Y-12 site; it has more than 61 90-day waste accumulation areas. RCRA violations have occurred, and citations have been received in the past; however, recent improvements in the program have been noted as exemplary by both TDC and EPA Region IV. A revised RCRA Part A permit application has been submitted to TDC but has not been approved (see Current Issues below for details).

Toxic Substances Control Act (TSCA)

PCBs are used, and PCB waste is generated at Y-12. The storage, control, and disposal of these are regulated by TSCA. A compliance issue does exist regarding the storage of uranium-contaminated PCB wastes beyond the TSCA 1-year limit (see Current Issues below for details).

Underground Storage Tanks (UST)

The Y-12 Underground Storage Tank Management Program manages 44 petroleum and hazardous substance USTs and former UST sites, including USTs less than 110 gallons. Twenty-eight USTs have been removed or inert-filled, and seven additional USTs are designated to be removed. Seven USTs installed since 1986 will be upgraded prior to compliance dates. Two USTs containing solid uranium oxide are deferred from upgrade requirements. Eight former UST sites are being addressed under site investigations and corrective action requirements.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The ORR was placed on the National Priorities List in November 1989. TDC, EPA, and DOE are negotiating a Federal Facility Agreement (FFA) that is now in final draft form. In January 1991, a 45-day comment review period on the FFA took place. No public comments were received. This FFA will address the remediation of inactive waste sites and waste storage areas.

National Environmental Policy Act (NEPA)

The Y-12 NEPA Program has issued Procedure 70-915, NEPA Review and Compliance, which outlines compliance guidelines to ensure that all plant projects receive a NEPA review and that projects are not initiated prior to NEPA determination from DOE. The Y-12 NEPA Program is utilizing 13 generic Categorical Exclusion (CX) documents to expedite project initiation. These CXs give blanket coverage to a wide range of activities such as routine maintenance, asbestos abatement, and tank removals. As of the end of the first quarter of 1991, a total of 647 CXs have been approved by DOE with 33 CXs pending approval. A total of 16 Environmental Assessments (EAs) are pending at DOE, awaiting direction to proceed or awaiting final approval. A wetlands study has been completed, and a report has been issued to provide baseline characterization data for NEPA activities. Completion of a floodplains study is dependent on an interagency agreement between DOE and the Tennessee Valley Authority. This study will be initiated as soon as the interagency agreement is in place.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Y-12 maintains compliance with FIFRA requirements through inspection of controlled pesticide/herbicide storage areas, and review of the on-site, restricted-use application program. A FIFRA Compliance Manual has been developed that sets forth the requirements for compliance with FIFRA and documents inspections of FIFRA storage areas.

Safe Drinking Water Act (SDWA)

Potable water is obtained from the treatment plant located on the Y-12 Plant. The treated water is tested for parameters listed under the state and federal drinking water regulations at various points throughout the plant distribution system. The water meets all health standards. Johnson Controls runs the program.

CURRENT ISSUES

A number of specific compliance issues have been identified as a result of recent intensive efforts to attain full compliance. During the first quarter of CY 1991, five new compliance issues were identified. Also during this first quarter of 1991, corrective actions were completed for six previously identified compliance issues. The significant issues are discussed below.

Air Permits

An ongoing inspection program for air emission sources has revealed a number of instances where permit applications do not contain sufficient detail to ensure compliance. Revisions for the applications are being made to provide sufficient data. A few instances have also been found where permit conditions and limits were being exceeded. These instances of technical noncompliance resulted in no exceedances of air quality standards and are being addressed on a case-by-case basis.

NESHAP Compliance

A compliance plan for complying with the NESHAP emissions monitoring requirements was developed for the ORR, including the Y-12 Plant. This plan was submitted to EPA Region IV in March 1990; however, in February 1991 the plan was rejected. A revised plan was prepared for submission in May 1991. It is expected that a Federal Facility Compliance Agreement (FFCA) between DOE and EPA for the ORR will be signed in 1991.

Unsampled NPDES Discharges

A field investigation of outfalls discharging to East Fork Poplar Creek identified several discharges that are not listed on the current NPDES permit. The outfalls have been incorporated into a Miscellaneous Discharge Sampling Plan and will be permitted in the new NPDES permit currently being negotiated for the Y-12 Plant.

Discharges of Toxic Pollutants

Y-12 was listed by TDC as a point source discharger of toxic priority pollutants under CWA Sect. 304(l). However, after further review of the flow in East Fork Poplar Creek, TDC revised the 304(l) listing and removed the Y-12 Plant from the list. Activities to reduce discharges of priority pollutants as well as other toxic agents such as chlorine and high temperature are continuing.

Steam Plant Ash Disposal

The discharge of bottom ash sluice from the Steam Plant to Rogers Quarry is being addressed by both interim and long-term projects. The projects are on schedule and are scheduled to be completed in 1993.

Land Disposal Restricted (LDR) Waste

RCRA mixed, radioactive land ban waste (including some nonradiological classified land ban waste) has been stored in some areas at Y-12 for longer than 1 year. These wastes are currently subject to the land ban that permits storage only for accumulation of sufficient quantities to facilitate proper treatment, recycle, or disposal. This waste is being stored because of the nationwide shortage of treatment and disposal facilities for these types of waste. Private-sector technology demonstrations are being conducted that involve uranium extractions from sludge. In addition, technology demonstrations are being planned for FY 1991 that will involve the removal of uranium and other metals from oils and solvents. DOE and EPA are continuing to discuss the issue, and the inventory of such waste is reported to the regulators on an annual basis. DOE's Oak Ridge Operations Office expects to negotiate an FFA that would detail the steps needed to attain compliance.

Uranium-Contaminated PCB Waste Storage

Uranium-contaminated PCB wastes are being stored in excess of the 1-year limit imposed by TSCA because of the lack of treatment and disposal capabilities. A compliance agreement with EPA is being pursued.

The K-1435 TSCA Incinerator that has been constructed at the Oak Ridge K-25 Site will be capable of incinerating PCB waste that is radioactive.

Y-12 Plant Internal Assessment

The purpose of this assessment was to identify all environmental compliance issues at the Y-12 Plant, regardless of whether or not the issues had been previously identified. The primary focus was to assess compliance with state and federal regulations, not DOE Orders, policies, procedures, or Best Management Practices. Specific regulatory areas included CAA, CWA, NEPA, RCRA, Solid Waste Disposal Act, TSCA, Superfund Amendments and Reauthorization Act, USTs, Aquatic Resources Alteration Permits, and FIFRA. The scope of the assessment included all buildings, separate work areas, processes within buildings, and outside areas associated with each building. Fifty-one findings were identified during the assessment, resulting in 21 new compliance issues added to the Y-12 Plant Environmental Compliance Report (Y/TS-550).

RCRA Part A Permit

The revised RCRA Part A Permit application was signed and submitted by DOE to TDC on July 27, 1990. Because of the lack of resolution of the owner/operator liability issue between Martin Marietta Energy Systems and DOE, Energy Systems did not sign the application. After resolution of the owner/operator issue, Martin Marietta signed as co-operator a revised Part A application. The revised application was submitted to TDC in September 1990. TDC is reviewing the revised Part A application. Without approval of the revised Part A from TDC, the following facilities are treating or storing RCRA waste or mixed-RCRA waste in excess of capacities or in locations not listed on the last Part A Permit application accepted by TDC in November 1988.

Cyanide Treatment Unit
RCRA and Mixed Waste Storage and Staging Unit
Disposal Area Remedial Action Liquid Storage/Treatment Unit
Building 9720-9 Storage Unit
Building 9206 Storage Unit
Building 9212 Storage Unit
Building 9206 Incinerator
Oil Landfarm Soils Storage Pad
Building 9201-4 Storage Unit

In addition, hazardous waste codes were not identified for P and U listings. The latest Part A revision submitted to TDC in February 13, 1991, included corrections and revisions to P and U list information.

DOE Environmental Assessment (Tiger Team)

In September and October 1989, a team of DOE environmental specialists conducted a comprehensive assessment of environmental practices at Y-12. The assessment covered the CWA, the CAA, the RCRA, the TSCA, Remedial Action Programs, radioactive emissions, NEPA, USTs, and environmental monitoring and surveillance. The assessment expressed concern over 24 compliance issues: 1 for the CAA, 4 for the CWA, 1 for hydrogeology, 6 for waste management, 3 for toxic materials management, 4 for radioactive emissions, and 5 for NEPA. Other practices relating to Best Management Practices were also examined. To date, 40 of the 62 total findings have been addressed and required actions completed.

CERCLA Reporting Requirements

A compliance assessment is currently being conducted to determine if continuous releases of hazardous substances reportable under 40 CFR 302.6(a) of CERCLA are occurring. If any releases are confirmed, the correct notifications will be made.

Fish Kill Investigations

On July 18, 1990, three dead fish were found in East Fork Poplar Creek (EFPC) between Lake Reality and Station 17 during a routine survey conducted as part of the Biological Monitoring and Abatement Program. Follow-up surveys performed at the creek for several days afterward led to the observation of additional dead fish. Daily stream surveys were continued throughout the remainder of the calendar year and resulted in the recovery of approximately 523 dead fish from EFPC since the kill was first noted.

Actions were undertaken to review various aspects of the EFPC environment in an effort to determine the cause of mortality to the creek aquatic life. Assessments of the stream water quality and the biological remains of the aquatic life resulted in a review of plant discharges. This revealed that releases of potable and once-through cooling waters were the major causes for the chlorine present in EFPC to exceed Tennessee water quality criteria. Studies were expanded to review other parameters that could be held liable for the adverse affects to the inhabitants of EFPC and include ongoing evaluations in levels of pH, temperature, and other constituents known to exist in these waters.

OAK RIDGE NATIONAL LABORATORY

COMPLIANCE STATUS

Clean Air Act (CAA) and National Emission Standards for Hazardous Air Pollutants (NESHAP)

ORNL is in compliance with state air regulations, including permitting requirements for all nonhazardous air pollution sources. Annual surveillance activities for the 106 permitted sources include verification that all permit conditions are being met and discussions with the operators pertaining to air emission issues or concerns. Of the nine major stacks, eight are either monitored or sampled for radiological emissions (the steam plant is not sampled or monitored for radiological emissions). The measured radiological emissions provided the basis for calculations of the ORNL annual radiological effective dose equivalent and conformance with NESHAP requirements.

On December 15, 1989, EPA issued new NESHAP regulations. Compliance with these requirements was required by March 15, 1990. A Monitoring Compliance Plan for all DOE facilities on the ORR was submitted to EPA Region IV. After extensive review, EPA Region IV has determined that the compliance plan does not meet regulatory requirements. A revised compliance plan will be submitted in May 1991 to the EPA Region IV for approval, and it is expected that an FFCA will be negotiated.

An evaluation of ORNL's laboratory research hoods for air permitting requirements has been completed. Based upon guidance provided by TDC, there are no laboratory hoods currently in operation at ORNL that require an air permit for chemically hazardous materials.

TDC inspected selected facilities on June 8, 1990, and no violations were noted.

Clean Water Act (CWA)

The ORNL NPDES permit, renewed in 1986, has more than 190 point source discharges that require compliance monitoring. The majority of these are storm drains, roof drains, parking lot drains, and storage area drains. Three major wastewater treatment facilities have been constructed since 1985: the Sewage Treatment Plant, the Coal Yard Runoff Treatment Plant, and the Nonradiological Wastewater Treatment Facility (NRWTF). Occasional spills, excursions, and precipitation runoff from storm and parking lot drains have resulted in NPDES permit effluent limits being exceeded for a variety of parameters. Progress continues toward minimizing or eliminating these occurrences. The compliance rate across all discharge points for the year was 98%. The NRWTF, which went online April 1, 1990, has operated without a single effluent discharge limit violation.

An application for renewal of the NPDES permit was submitted to TDC on September 28, 1990, in accordance with the 5-year permitting cycle. The 1986 permit expired on March 31, 1991; the expired permit will remain in effect until the new permit is issued.

In response to Section 304(l) of the CWA, TDC modified the permit in July 1990 to include a more stringent limit on selenium discharge. The selenium limit has not been exceeded to date.

Numerous construction activities throughout the ORNL site have the potential to impact the local surface streams. ORNL has applied for and received nine approvals for such projects from the U.S. Army Corps of Engineers. The projects were provided permits under the requirements of 33 CFR. 330.5, "U.S. Army Corps of Engineers Nationwide Permits." Five aquatic resource alterations permits have been issued to ORNL by TDC.

A compliance Evaluation Inspection was conducted by the EPA Region IV on June 21, 1990. ORNL received a score of 4 out of a possible 5. Only a few minor deficiencies were noted.

Resource Conservation and Recovery Act (RCRA)

ORNL generates both RCRA hazardous waste and RCRA hazardous waste mixed with radionuclides (i.e., mixed hazardous waste). The hazardous waste is accumulated by individual generators at several satellite accumulation areas where it is picked up by waste management personnel and stored in permitted storage facilities until it is shipped off-site for treatment and/or disposal at a RCRA-permitted facility. ORNL has two RCRA-permitted hazardous waste storage units and several others that operate under RCRA interim status. Mixed waste must be stored on-site because of the nationwide shortage of facilities currently available for treatment and/or disposal. In accordance with guidance provided by TDC, ORNL is working to consolidate Part B Permit applications. Five general categories (container storage, transuranic container storage, tank storage, chemical detonation treatment, and transuranic treatment) have been proposed. Current plans include at least 11 units distributed among these 5 categories.

Major RCRA activities for 1990 included the submittal to TDC of a Closure Plan for the interim closure of Building 3001 Storage Canal. TDC has issued the Storage Canal plan for public comment. ORNL also provided a tour of the chemical detonation facilities for representatives of EPA Region IV. Information gathered by EPA on this visit will assist in the preparation of a guidance document for the permitting of such facilities.

Several facilities that currently operate under interim status are scheduled for closure, projected to be initiated or completed by November 1992. The most recent RCRA inspection by TDC (February 1990) resulted in no violations or deficiencies.

Toxic Substances Control Act (TSCA)

ORNL operates research equipment that contains PCB capacitors. It also operates some miscellaneous equipment and transformers, pumps, electric motors, etc., that contain oil contaminated with PCBs. Both radioactive and nonradioactive PCB wastes are stored on-site in enclosed storage. The nonradioactive PCBs are transported off-site to EPA-approved facilities for disposal in accordance with regulatory requirements. Two drums of radioactively contaminated PCB waste are currently stored on-site awaiting disposal at the TSCA Incinerator at the Oak Ridge K-25 Site. EPA conducted a TSCA inspection of ORNL facilities in February 1990, and no nonconformances with regulatory requirements were cited.

Underground Storage Tanks (USTs)

The UST regulations (40 CFR Pt. referred to as Subtitle I) require that all underground tanks storing petroleum products or hazardous substances be in compliance with specific technical standards within a period of 10 years from the date of adoption of the final regulations. Tanks that were in existence prior to the issuance of the regulations are required to be upgraded during this 10-year period to meet the standards or are taken out of service. TDC has also promulgated state UST regulations that attempt to mirror the federal regulations.

ORNL has developed a UST Management Program that includes implementation of leak detection, corrosion protection, spill and overflow protection, annual tightness testing, operational controls, record keeping, reporting, and replacement of certain UST systems that cannot be upgraded by 1998. The program addresses the immediate removal from service and remediation of sites with tanks found to be leaking as well as implements any required closures, corrective actions, and any upgrading and/or replacement of affected USTs in accordance with the program plan. Additionally, the program also ensures that the installation of new USTs meets the minimum design standards.

ORNL has a total of 60 tanks that are potentially subject to the UST regulations. Six of these USTs are currently subject to the regulations, of which four have been taken out of service and removed from the ground. The remaining 54 tanks are either deferred (until 1998) or excluded from the regulations. However, all USTs are being managed as if they were subject to the regulations.

As of December 1990, a total of 19 USTs (4 in CY 1990) have been excavated or filled with sand, 8 remedial actions are ongoing, and 3 closures are scheduled for CY 1991.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The ORR was placed on the National Priorities List in November 1989. TDC, EPA, and DOE have negotiated an FFA that is now in final draft form. A 45-day public comment period was provided, beginning in January 1991. No comments were received. This FFA will address the remediation of inactive waste sites and waste storage areas on the ORR. The FFA will also address technical standards for new and existing liquid low-level radioactive waste (LLLW) storage tanks, including disposition of leaking LLLW tank systems.

National Environmental Policy Act (NEPA)

ORNL is in compliance with NEPA. This compliance is achieved and maintained through the efforts of the Environmental Review and Documentation Section (ERDS) of the Office of Environmental Compliance and Documentation. Part of the environmental review for a new project by the ERDS also includes an assessment of the impact or involvement of endangered species, historic sites, floodplains, and wetlands. In addition, an ORR Floodplain/Wetlands survey is scheduled for completion by early 1991.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

ORNL maintains compliance with FIFRA requirements through inspection of controlled pesticide/herbicide storage areas, and review of the on-site, restricted-use application program. A FIFRA Compliance Manual has been developed that sets forth the requirements for ORNL compliance with FIFRA, documents inspections of FIFRA storage areas, and serves as the basis for development of a general ORNL procedure that will be included in the revised Environmental Protection Manual.

Safe Drinking Water Act (SDWA)

Potable water is obtained from the treatment plant located on the Y-12 Plant. The treated water is tested for parameters listed under the state and federal drinking water regulations. The water meets all health standards.

CURRENT ISSUES

A number of specific compliance issues have been identified. Some of the most significant issues are discussed below.

Land Disposal Restricted (LDR) Waste

Currently, ORNL is storing LLLW that contains RCRA hazardous waste (mixed waste) that is subject to the Land Disposal Restrictions. Storage is allowed only for accumulating sufficient quantities to facilitate treatment, recycle, or disposal. This waste is being stored indefinitely because of the lack of treatment or disposal facilities for this type of mixed waste. DOE and EPA are continuing to discuss the issue. DOE expects to negotiate an FFCA with EPA that would detail the steps needed to attain compliance. A draft FFCA that addresses spent solvent and California List mixed-waste streams is under preparation.

The K-1435 TSCA Incinerator that has been constructed at the Oak Ridge K-25 Site is capable of incinerating liquid organic waste that is hazardous and radioactive.

Mixed TSCA Waste Storage

Radioactively contaminated PCB wastes (i.e., mixed wastes) are being stored in excess of the 1-year limit imposed by TSCA because of the lack of treatment and disposal capabilities. A compliance agreement with EPA is being pursued.

The K-1435 TSCA Incinerator that has been constructed at the Oak Ridge K-25 Site will be capable of incinerating liquid PCB wastes.

Contaminants Resulting from Storm Runoff

Precipitation runoff has resulted in total suspended solids (TSS) and oil and grease values that persistently exceed NPDES effluent limits at storm drain and parking lot drain outfalls. Studies have been initiated to identify potential corrective measures along with the feasibility of implementation. Based on evidence that the NPDES exceedances of TSS and oil and grease experienced over the past 2 years do not appear to have a significant impact on the water quality of the White Oak Creek watershed and on exemptions from NPDES permitting requirements provided by EPA's proposed regulations governing stormwater runoff from parking lots, a request for a modification to ORNL's NPDES permit has been submitted to TDC. The proposal was also included in ORNL's NPDES permit renewal application submitted to TDC on September 28, 1990.

Ethylene Glycol Spills

It is suspected that slow releases of ethylene glycol to surface streams are occurring from the Central Chilled Water Facility in the main plant complex at ORNL. Occasional ethylene glycol spills also occur that enter surface waters. Although ethylene glycol is not a toxic pollutant, it results in the generation of an oxygen demand on the receiving stream that can be detrimental to aquatic organisms. An action plan has been developed by ORNL for replacement of ethylene glycol with water coolant. Pending receipt of TDC authorization for implementation of the plan, ORNL is replenishing the system with water, rather than using water-ethylene glycol solutions as in the past. The ethylene glycol wastewater is transported to the Y-12 Plant for use as a carbon source in their wastewater treatment facility (Biodenitrification Facility).

In instances where major ethylene glycol spills occur, containment is provided as soon as practicable to minimize releases to surface waters. Agreements are being negotiated with TDC to allow treatment of these contained wastes through on-site conventional wastewater treatment facilities for subsequent discharge through NPDES-permitted outfalls.

Releases from Burial Grounds and Waste Disposal Areas

Radionuclides and chemical constituents released from inactive burial grounds and other waste disposal areas have been found in groundwater and surface water in the Bethel Valley and Melton Valley areas of ORNL. Major known releases include strontium, cesium, cobalt, and tritium as well as hazardous, organic, and inorganic constituents. ORNL has established an Environmental Restoration Program to provide comprehensive management and remediation of those areas where past research, development, and waste management activities have been conducted and have resulted in residual contamination of facilities or releases to the environment. The FFA between DOE and EPA will address selections of corrective measures and schedules for implementation.

Tiger Team Assessment

The Tiger Team review of ORNL conducted from October 22, 1990, to November 30, 1990, resulted in 70 findings in the environmental area. Forty-three of the findings were associated with compliance with internal procedures, corporate policies, or regulatory requirements. The balance of the findings addressed Best Management Practices.

Revision 3 of the ORNL Corrective Action Plan in Response to Tiger Team Assessment was transmitted to DOE-HQ for review and comment in February 1991. Comments have been received and are under consideration. Revision 4 will be issued as soon as possible.

CERCLA Reporting Requirements

Spills and unanticipated releases are evaluated to determine if reportable under CERCLA as prescribed under 40 CFR 302.6(a). ORNL had one reportable event in 1990.

To determine compliance with the requirements of 40 CFR 302.8, Continuous Releases, a compliance assessment is currently being conducted. If any reportable continuous releases are confirmed, appropriate notifications will be made.

OAK RIDGE K-25 SITE

COMPLIANCE STATUS

Clean Air Act (CAA)

At present, approximately 125 air permits for operations exist at the K-25 Site. The compliance activity issues associated with CAA regulations include (1) asbestos abatement under NESHAP requirements; (2) the opacity excursions that occur when coal is used during peak power demands as a supplemental fuel source at the steam plant, and (3) new regulatory requirements under NESHAP for radionuclide emissions. The asbestos abatement issue has been addressed using an aggressive program for the removal and/or encapsulation of deteriorating asbestos in identified areas and for the formalization of all procedures for asbestos work. Current efforts are focusing on ensuring that all sources are permitted and are operating (1) in accordance with those permits, (2) in compliance with the new NESHAP regulations for radionuclide emissions, and (3) in accord with ongoing work to eliminate opacity excursions.

Clean Water Act (CWA)

The compliance activity issue associated with CWA regulations includes excursions outside the NPDES permit discharge limits. The K-25 Site has one NPDES permit that was issued by TDC pertaining to eight discharge locations. Approximately 22,000 analyses are performed annually as required by the existing NPDES permit. Even though a 99%-plus compliance rate is experienced, occasional excursions occur outside the NPDES discharge limits. Each time an excursion is experienced, a quality investigation is conducted to identify causes and corrective actions to prevent future occurrences. Approximately half of the excursions experienced are for aluminum at the Mitchell Branch sampling station and chemical oxygen demand (COD) at the K-1007-B pond outfall. These excursions are believed to be the result of natural occurrences during periods of heavy rainfall and not process related. DOE has requested variances from TDC for aluminum and COD at these locations.

Corrective actions relating to the NPDES Program include identifying projects to treat and/or remove nonpoint source discharges. These projects include the rehabilitation of sanitary sewer lines to prevent infiltration, the removal and/or treatment of effluents to storm drains to remove residual chlorine, and the remediation of sites that may be contributing to surface water contamination.

Resource Conservation and Recovery Act (RCRA)

The Oak Ridge K-25 Site has entered into an agreement with TDC to combine and modify all Part B permits applications into three applications. These three units will consist of (1) the K-1435 TSCA Incinerator; (2) the K-1435 and K-1425 TSCA Storage and Feed Units; and (3) all the other units combined. The K-1435 incinerator and ten of the K-25 vaults have been permitted. All other units are operations under interim status. Eight withdrawal alleys and one vault have been approved for interim status. EPA and TDC have granted approval for the storage of the K-1417 stabilized and unstabilized sludge. These units will be added to the Part A permit application in 1991.

Toxic Substances Control Act (TSCA)

Dielectric fluids contaminated with PCBs are used, and PCB wastes are generated at the K-25 Site. In addition, PCB wastes generated at other DOE Oak Ridge Operations sites are stored at the K-25 Site pending disposal at the K-1435 TSCA Incinerator. The storage, control, and disposal of these PCB wastes are regulated by TSCA. Compliance issues exist regarding PCB leaks from shutdown process building ventilation system gaskets and the storage of uranium-contaminated PCB wastes beyond the TSCA 1-year limit (see Current Issues below for details).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The ORR was placed on the National Priorities List in November 1989. TDC, EPA, and DOE are negotiating an FFA that is now in final draft form. Signing of the FFA is anticipated in the summer of 1991. This FFA will address the remediation of inactive waste sites and waste storage areas.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The K-25 Site maintains compliance with FIFRA requirements through inspection of controlled pesticide/herbicide storage areas, and review of the on-site, restricted-use application program. A FIFRA Compliance Manual has been developed that sets forth the requirements for compliance with FIFRA, documents inspections of FIFRA storage areas, and serves as the basis for development of a general procedure that will be included in the revised Environmental Protection Manual.

Safe Drinking Water Act (SDWA)

The K-25 Site operates a sanitary water system to provide potable water. This system consists of a raw water-pumping station on the Clinch River, a filtration and treatment plant, finished water storage tanks, and a distribution system. Monthly reports are provided to the state of Tennessee detailing the water quality of the facility. The facility operator has a Class IV Water Operator Certification from the state.

CURRENT ISSUES

A number of specific compliance issues have been identified as a result of recent intensive efforts to attain full compliance. The significant issues are discussed below.

NESHAP Compliance

A compliance plan for complying with the NESHAP emissions monitoring requirements was developed for the ORR, including the K-25 Site. This plan was submitted to EPA Region IV in March 1990; however, in February 1991 the plan was rejected. A revised plan was prepared for submission in May 1991. It is expected that an FFCA between DOE and EPA for the ORR will be signed in 1991.

Discharges of Toxic Pollutants to Surface Waters

The K-25 Site has been listed by EPA and TDC as a point source discharger of toxic priority pollutants under CWA Sect. 304(l). Activities to reduce discharges of priority pollutants as well as other toxic agents such as chlorine and high temperature will be required. Projects to address toxic contributors have been approved, and measures are being taken to eliminate these pollutants.

Steam Plant Opacity Problems

The opacity problem at the K-25 Site Steam Plant is being resolved by replacing coal-fired boilers with gas-fired boilers. One gas-fired boiler has been installed, and a second is scheduled for installation in 1991. Actions have been taken to eliminate completely the use of coal at the K-25 Site.

Land Disposal Restricted Waste

RCRA mixed, radioactive land ban waste (including some nonradiological classified land ban waste) has been stored in some areas at K-25 for longer than 1 year. These wastes are currently subject to the land ban that permits storage only for accumulation of sufficient quantities to facilitate proper treatment, recycling, or disposal. This waste is being stored because of the nationwide shortage of treatment and disposal facilities for these types of waste. Private-sector technology demonstrations are being conducted that involve uranium extractions from sludge. In addition, technology demonstrations are being planned for FY 1991 that will involve the removal of uranium and other metals from oils and solvents. DOE and EPA are continuing to discuss the issue, and the inventory of such waste is reported to the regulators on an annual basis. DOE's Oak Ridge Operations Office expects to negotiate an FFCA that would detail the steps needed to attain compliance.

Mixed TSCA Waste Storage

Uranium-contaminated PCB wastes (i.e., mixed wastes) are being stored in excess of the 1-year limit imposed by TSCA because of the lack of treatment and disposal capabilities. The FFCA for PCB gaskets addresses this compliance issue. It also addresses the ~10,000 pieces of nonradioactive PCB-containing dielectric equipment associated with the shutdown of diffusion plant operations.

The K-1435 TSCA Incinerator that has been constructed at the Oak Ridge K-25 Site will be capable of incinerating organic waste that is hazardous and radioactive. In 1990, a limited amount of waste was incinerated as a part of the startup testing. The incinerator is scheduled to be fully permitted in 1991.

K-1417 Storage Yard

In 1989, during routine inspections of the drums of stabilized K-1407 Pond sludge at the K-1417 Storage Facility, it was discovered that many of the drums had begun to corrode. Free liquid (water with pH of 12) on top of the concrete in the drums was found to be causing the corrosion. A task team was formed to evaluate the problem. Steps were taken to identify the drums containing water and remove the water. In 1990, approximately 8300 drums of stabilized sludge were dewatered and moved to storage vaults within the K-25 Building. An additional 3000 drums were dewatered and remained in storage at K-1417. The water was collected and disposed of through the Central Neutralization Facility (CNF).

In July 1990, several teams were formed by DOE and Martin Marietta Energy Systems to investigate the compliance issues concerning the K-1417 Storage Yard. The teams' findings included events that contributed to the noncompliances and potential recommendations to correct the noncompliances.

Sampling of the runoff from the storage yard was initiated, and the results are maintained for trending analysis. Initial results from the runoff sampling indicate that the beta activity is slightly above the background levels for the area.

CERCLA Reporting Requirements

A compliance assessment is currently being conducted to determine whether current releases of hazardous substances reportable under 40 CFR 302.6(a) of CERCLA are occurring. If any releases are confirmed, the correct notifications will be made.

PCB-Containing Ventilation System Gaskets

Lubricating oil that seeps through PCB-containing ventilation system gaskets in the shutdown process buildings and drips to the floor is considered a PCB spill. TSCA requires immediate cleanup action, documentation, and verification after discovery. New drips from ventilation gaskets are cleaned in general accordance with the EPA Spill Cleanup Policy as contained in TSCA. This includes periodic inspections to identify leaks and initiation of cleanup within 24 hours. Sampling to verify cleanup, however, is performed only on a representative basis rather than for each spill as required by TSCA policy. Drip collection troughs are installed when leaks are discovered. DOE and EPA are negotiating an FFCA to bring the facility into compliance with TSCA regulations for use, storage, and disposal of PCBs.

National Environmental Policy Act (NEPA) Program Deficiencies

The NEPA program at the K-25 Site is progressing toward a more structured approach with a NEPA Management Plan. The plan provides for training of key site personnel, tracking of NEPA documentation preparation and approval, K-25 NEPA implementation procedures, and tracking of NEPA commitments. Draft DOE procedures for NEPA compliance were published in the Federal Register on November 2, 1990. The K-25 Site procedures have been drafted in a manner consistent with DOE procedures and DOE-ORO guidance. Corrective action will continue and will principally involve implementation of procedures, training, and tracking.

CONTENTS

ACRONYMS AND INITIALISMS

AA	atomic absorption
ACD	Analytical Chemistry Division
ACL	alternate concentration limit
ACN	acetonitrile
ADI	acceptable daily intake
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AGM	average geometric mean
ALARA	as low as reasonably achievable
Am	americium
As	arsenic
ASTM	American Society for Testing and Materials
ATLC	Atomic Trades and Labor Council
AVLIS	atomic vapor laser isotopic separation
BAT	best available technology
BC	Beaver Creek
BCBG	Bear Creek Burial Grounds
BCHR	Beaver Creek Hydrogeologic Regime
BCK	Bear Creek kilometer
BCV	Bear Creek Valley
BCVWDA	Bear Creek Valley Waste Disposal Area
BF	Brushy Fork
Bq	becquerel
BMAP	Biological Monitoring and Abatement Programs
BMP	best management practices
BOD	biological oxygen demand
BRC	below regulatory concern
BTM	breakthrough monitors
CAA	Clean Air Act
CAPCA	Closure and Post Closure Activities
CARL	Comparative Animal Research Laboratory
CAS	Chemical Abstracts Service
CC	Copper Creek
CDI	calculated daily intake
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CH	contact-handled
Ci	curie
CLP	Contract Laboratory Program
Cm	curium
CNF	Central Neutralization Facility
Co	cobalt
COD	chemical oxygen demand
CPCF	Central Pollution Control Facility
CRDL	contract-required detection limit
CRHR	Chestnut Ridge Hydrogeologic Regime

CRK	Clinch River kilometer
CRSDP	Chestnut Ridge Sediment Disposal Basin
CRSP	Chestnut Ridge Security Pits
Cs	cesium
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year
CYRTF	coal yard runoff treatment facility
d	day
DCF	dose conversion factor
DCG	derived concentration guide
diam	diameter
DMR	Discharge Monitoring Report
DNA	deoxyribonucleic acid
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DWL	drinking water limits
EA	Environmental Assessment
EAP	Environmental Assessment Plan
EDE	effective dose equivalent
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EMSL-LV	Environmental Monitoring System Laboratory at Las Vegas
EP	extraction procedure
EPA	Environmental Protection Agency
ERDS	Environmental Review and Documentation Section
ERP	Environmental Restoration Program
E&SA	Environmental and Safety Activities
ESD	Environmental Sciences Division
FAC	free available chlorine
FDA	Food and Drug Administration
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	feasibility study
FWPLA	Federal Water Pollution Control Act
g	gram
GQM	groundwater quality monitoring
GUT	garage underground tank
GW	groundwater
GWPP	Groundwater Protection Program
GWPS	Groundwater Protection Standard
GWQAP	groundwater quality assessment plans
GWQAR	groundwater quality assessment reports
h	hour
H	hydrogen

ha	hectare
HAZWDDD	Hazardous Waste Development, Demonstration, and Disposal
HEPA	high-efficiency particulate air
HFIR	High Flux Isotope Reactor
Hg	mercury
HSWA	Hazardous and Solid Waste Amendments
HWDU	hazardous waste disposal unit
I	iodine
IAG	interagency agreement
IBI	Index of Biotic Integrity
ICP	inductively coupled plasma
ICRP	International Commission on Radiological Protection
IRIS	Integrated Risk Information System
IWC	instream waste concentration
IWMF	Interim Waste Management Facility
K	Kingston
kg	kilogram
KHQ	Kerr Hollow Quarry
km	kilometer
Kr	krypton
L	liter
LCR	lowest concentration reported
LDR	land disposal restricted
LLLW	liquid low-level waste
LLW	low-level waste
LLWDDD	low-level waste disposal development and demonstration
LLWDF	Low-Level Waste Disposal Facilities
LSF	Liquid Storage Facility
m	meter
MAA	material access area
mg	milligram
MB	Melton Branch
MCL	maximum contaminant level
MDL	method detection limits
MDA	minimum detectable activity
Mgd	million gallons per day
MHD	Melton Hill Dam
min	minute
mm	millimeter
mrem	millirem
MT	meteorological tower
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act
ND	not detected
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHP	New Hope Pond
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NOEC	no-observed-effect concentration

NOV	Notice of Violation
Np	neptunium
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRWTF	Nonradiological Wastewater Treatment Facility
NWT	Northwest Tributary
O&G	oil and grease
OLF	Oil Landfarm Area
ORAU	Oak Ridge Associated Universities
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation
ORRER	Oak Ridge Reservation Environmental Report
Pa	protactinium
P&A	plugging and abandonment
PA	preliminary assessment
PAM	perimeter air monitor
Pb	lead
PC	Pond Closure
PCB	polychlorinated biphenyl
pCi	picocurie
PCP	pentachlorophenol
PET	Proficiency Environmental Testing
PGDP	Paducah Gaseous Diffusion Plant
PIDAS	Perimeter Intrusion Detection and Alarm System
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRTF	Plating Rinsewater Treatment Facility
Pu	plutonium
pvc	polyvinyl chloride
PWTP	process waste treatment plant
QA	quality assurance
QC	quality control
Ra	radium
RAM	remote air monitor
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
R&D	research and development
REDC	Radiochemical Engineering Development Center
RFA	RCRA Facility Assessment
Rfd	reference dose
RFI	RCRA facility investigation
RH	remote-handled
RMA	Rocky Mountain Arsenal
RWMD	Reservation Waste Management Division
S-3	S-3 Site
S&A	sampling and analysis

SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
Se	selenium
SE	standard error of the mean
SERAM	Stack Emission Reduction and Monitoring Project
SF	slope factor
SIE	specific ion electrode
SMCL	secondary maximum contaminant level
SO	sulfur dioxide
SOP	standard operating procedure
SPAD	Steam Plant Ash Disposal
SPCC	Spill Prevention, Control, and Countermeasures
SPWTF	Steam Plant Wastewater Treatment Facility
Sr	strontium
STP	sewage treatment plant
SWMU	solid waste management unit
SWSA	solid waste storage areas
Tc	technetium
TCLP	toxicity characteristic leaching procedure
TCMP	toxicity control and monitoring program
TDC	Tennessee Department of Conservation (formerly TDHE)
TDHE	Tennessee Department of Health and Environment (now TDC)
TDS	total dissolved solids
Th	thorium
TOC	total organic carbon
TOX	total organic halogens
TRE	Toxicity Reduction Evaluation
TRK	Tennessee River kilometer
TRU	transuranic
TSCA	Toxic Substances Control Act
TSF	Tower Shielding Facility
TSP	total suspended particulates
TSS	total suspended solids
TSWMA	Tennessee Solid Waste Management Act
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
U	uranium
UEFPC	Upper East Fork Poplar Creek
UEFPCHR	Upper East Fork Poplar Creek Hydrogeologic Regime
UF	uranium hexafluoride
UNC	United Nuclear Corporation
USGS	United States Geological Survey
UST	underground storage tank
VC7002	Vehicle Cleaning Facility
VOA	volatile organic aromatics
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area grouping
WCPF	Waste Coolant Processing Facility
WETF	West End Treatment Facility

WIPP	Waste Isolation Pilot Plant
WMA	Waste Management Area
WMCBF	Waste Machine Coolant Biodegradation Facility
WOC	White Oak Creek
WOCE	White Oak Creek Embayment
WOCH	White Oak Creek Headwaters
WOD	White Oak Dam
WOL	White Oak Lake
WOM	White Oak Mountain
WTF	Waste Treatment Facility
Xe	xenon

INTRODUCTION

1. INTRODUCTION

The purpose of this report is to provide information to the public about the impact of the U.S. Department of Energy's (DOE's) facilities located on the Oak Ridge Reservation (ORR) on the public and the environment. It describes the environmental surveillance and monitoring activities conducted at and around the DOE facilities operated by Martin Marietta Energy Systems, Inc. Preparation and publication of this report is in accordance with DOE Order 5400.1. The order specifies a publication deadline of June of the following year for each calendar year of data.

The primary objective of this report is to summarize all information collected for the previous calendar year regarding effluent monitoring, environmental surveillance, and estimates of radiation and chemical dose to the surrounding population. When multiple years of information are available for a program, trends are also evaluated. The first seven sections of Volume 1 of this report address this objective. The last three sections of Volume 1 provide information on solid waste management, special environmental studies, and quality assurance programs. Chemicals covered by the Superfund Amendments and Reauthorization Act (SARA) Title III 313 Report on gaseous emissions are included in Appendix C. Volume 2 is a compilation of the data that are summarized in Volume 1 and relevant descriptive reference material that does not change from year to year. Volume 2 is not intended to be a stand-alone report.

1.1 OPERATIONS ON THE OAK RIDGE RESERVATION

The ORR is located within the corporate limits of the city of Oak Ridge in eastern Tennessee. The ORR consists of about 14,300 ha (35,300 acres) of federally owned lands. The location of Oak Ridge and the ORR is shown on the map of Tennessee in Fig. 1.1. The ORR site is predominantly to the west and south of the population center of the city, which has a population of 28,000. Oak Ridge lies in a valley between the Cumberland and southern Appalachian mountain ranges and is bordered on one side by the Clinch River. The Cumberlands are about 16 km (10 miles) northwest; 113 km (70 miles) to the southeast are the Great Smoky Mountains, as shown in Fig. 1.1.

The ORR contains three major operating facilities: Oak Ridge Y-12 Plant (Y-12 Plant), Oak Ridge National Laboratory (ORNL), and Oak Ridge K-25 Site (K-25 Site). The locations of these three facilities are shown on the map of the ORR (Fig. 1.2). The on-site DOE buildings and structures outside the major plant sites consist of the Scarboro Facility, Clark Center Recreational Park, Central Training Facility, and the Transportation Safeguards Division maintenance facility. The off-site DOE buildings and structures consist of the Federal Office Building, Office of Scientific and Technical Information, Oak Ridge Associated Universities (ORAU), Atmospheric Turbulence and Diffusion Division—National Oceanographic and Atmospheric Administration, the American Museum of Science and Energy, Energy Systems administrative support office buildings, and the former museum building. The administrative units (units managed by a major installation or by central Energy Systems) on the ORR are shown in Table 1.1. in Vol. 2.

The Y-12 Plant (Fig. 1.3), which is immediately adjacent to the city of Oak Ridge, has five major responsibilities: (1) to fabricate nuclear weapon components, (2) to process source and special nuclear materials, (3) to provide support to the weapons design laboratories, (4) to provide support to other Martin Marietta Energy Systems, Inc., installations, and (5) to provide support to other government agencies. Activities associated with these functions include production of lithium compounds, recovery of

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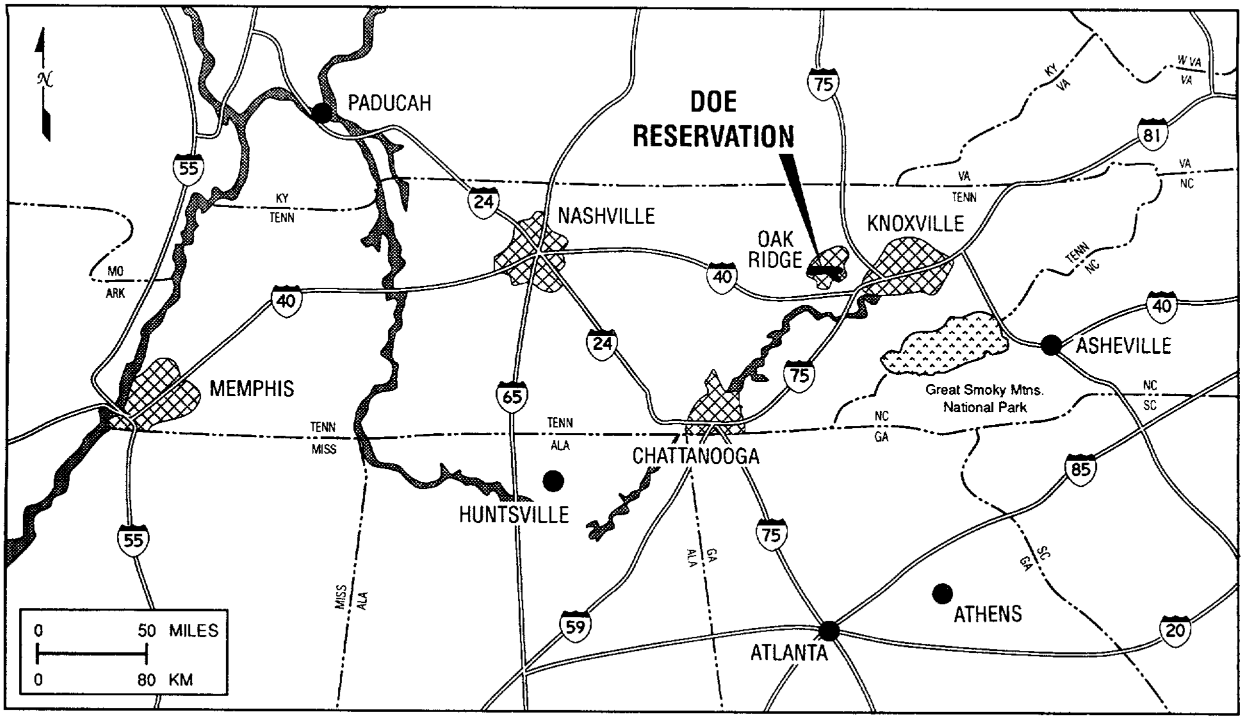

Fig. 1.1. Map showing location of Oak Ridge and the Oak Ridge Reservation in relationship to geographic region.

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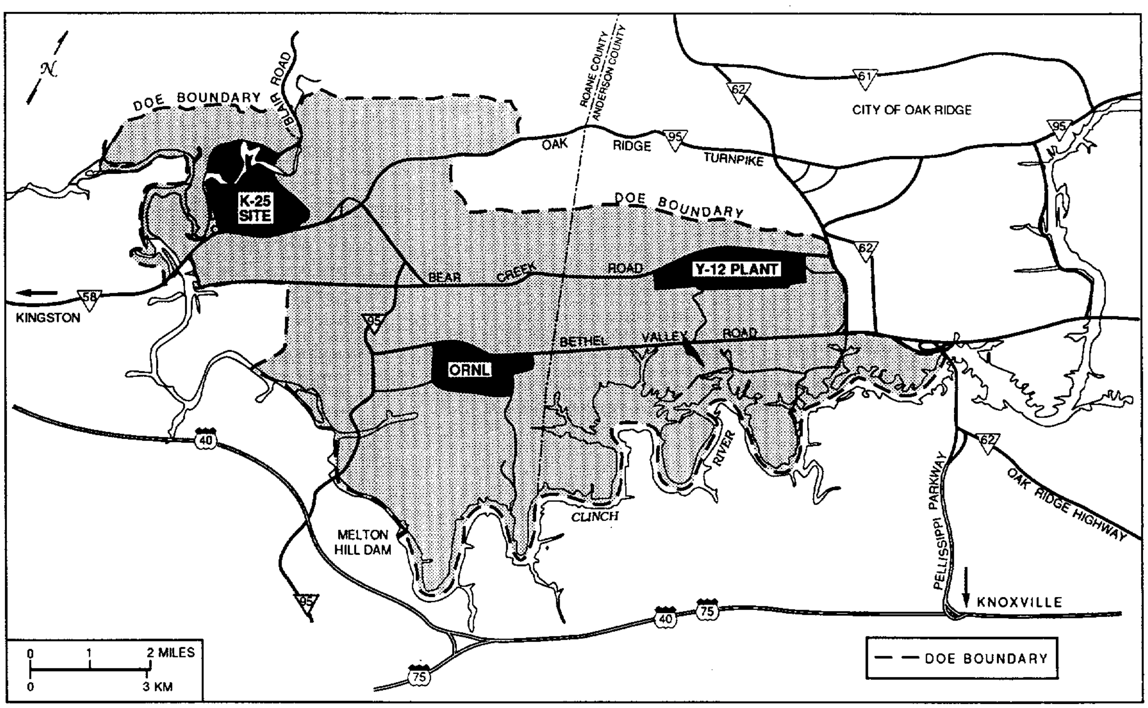

Fig. 1.2. Map showing the Department of Energy's Oak Ridge Reservation and the location of the three major installations.

Y-12 PHOTO 253352

Fig. 1.3. Oak Ridge Y-12 Plant (view looking northwest).

enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

ORNL (Fig. 1.4), located toward the west end of Bethel Valley, is a large, multipurpose research laboratory whose basic mission is to expand knowledge, both basic and applied, in areas related to energy. To accomplish this mission, ORNL conducts research in fields of modern science and technology. ORNL's facilities include nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, accelerators, fusion test devices, and support facilities. The Oak Ridge National Environmental Research Park is managed by ORNL. All of ORNL's reactors were shut down in 1986 while efforts were under way to improve operating procedures and safety standards for the facilities. The High Flux Isotope Reactor (HFIR) and the Tower Shielding Facility (TSF) resumed operation in 1990. In addition to the main ORNL complex, the ORNL Biology and Fusion Energy divisions and staff from other ORNL divisions are located at the Y-12 Plant, and the Applied Technology Division is located at the K-25 Site.

Until the summer of 1985, the primary mission of the K-25 Site (Fig. 1.5) was enrichment of uranium hexafluoride (UF_6) in the ^{235}U isotope for use as a fuel in nuclear reactors. The gaseous diffusion process was utilized to produce the enrichment services. In August 1985, the gaseous diffusion process at the K-25 Site was placed in a "ready standby" mode because of declining demands for enriched uranium. The decision to permanently shut down the gaseous diffusion cascade was made in December 1987.

In addition to operating the gaseous diffusion process, K-25 Site personnel were involved in developing and demonstrating more energy-efficient and cost-effective methods for uranium enrichment. Two such methods under development at the K-25 Site were the gas centrifuge process and the atomic vapor laser isotopic separation (AVLIS) system. In 1985 the gas centrifuge process was shut down, and in 1986 the AVLIS work at the K-25 Site was significantly reduced.

ORNL PHOTO 2220-86

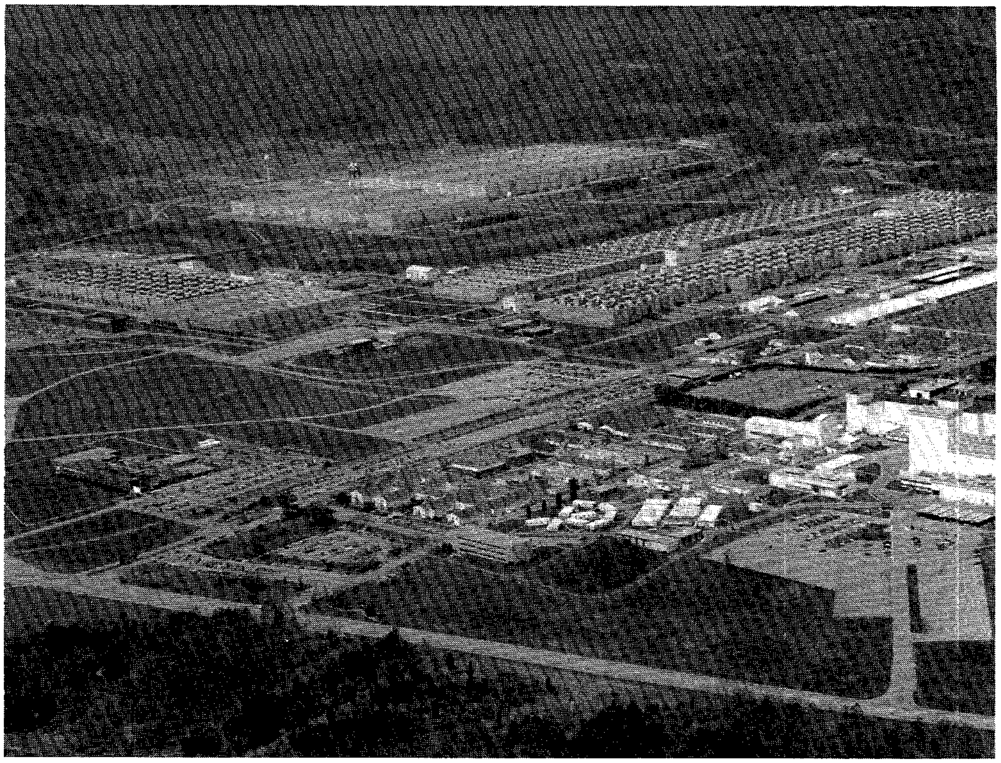

Fig. 1.4. Oak Ridge National Laboratory (view looking west).

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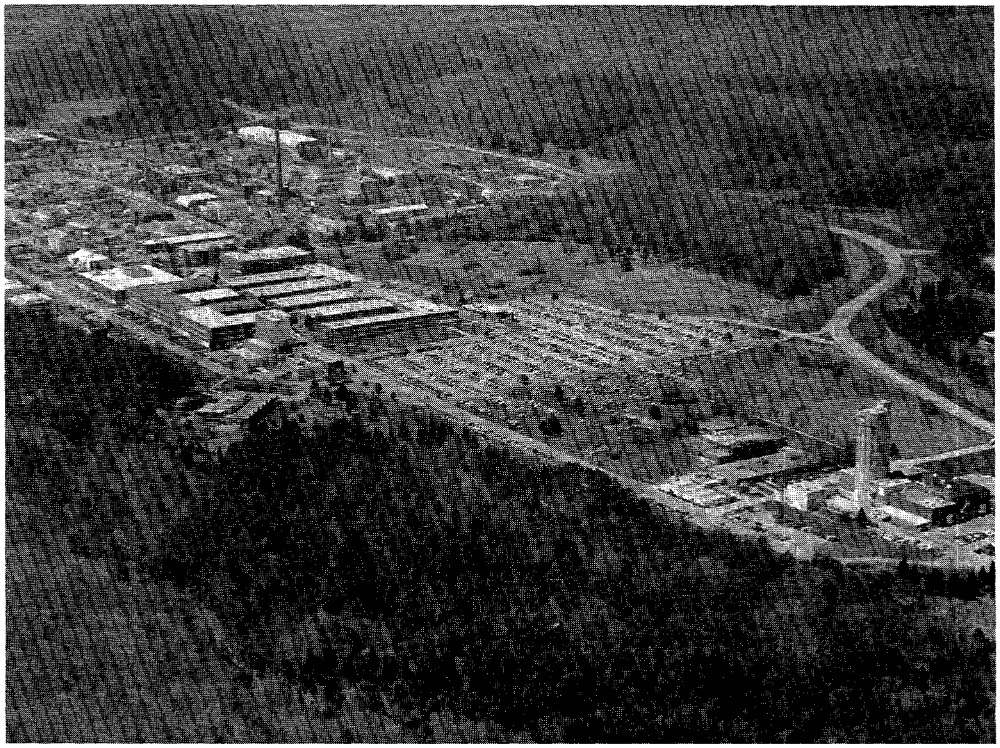

Fig. 1.5. Oak Ridge K-25 Site (view looking northwest).

Major changes in the role of the K-25 Site began evolving during 1986 and 1987. A significant increase in work for agencies other than DOE is projected in the future. The unique technologies, expertise, and facilities at the K-25 Site constitute a national resource that can effectively be used to solve problems of national importance in areas that complement the ongoing DOE missions. Although enrichment operations at the K-25 Site are shut down, some waste streams are being generated, and wastes now in storage will require disposal in the future.

Waste management activities at the K-25 Site are increasing. Low-level radioactive wastes from other DOE-Oak Ridge Operations (ORO) sites are now being placed in the K-25 Building vaults until the final disposition strategy is identified. Also, polychlorinated biphenyl (PCB) wastes contaminated with uranium began arriving from other DOE-ORO sites in 1987 for incineration in the K-1435 Toxic Substances Control Act (TSCA) Incinerator.

Other remaining missions at the K-25 Site include advanced enrichment technology research and development, analytical laboratory programs, engineering and computer support, and waste treatment services.

Operations associated with the DOE research and production facilities in Oak Ridge produce several types of waste materials. Radioactive wastes are generated from nuclear research activities, weapons production, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, and uranium processing operations. Nonradioactive (including hazardous) wastes are generated by normal industrial-type support facilities and operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plants, and steam plants.

Nonradioactive, nonhazardous solid wastes are buried in the Tennessee Department of Conservation (TDC)-permitted Centralized Sanitary Landfill II, operated by the Y-12 Plant, or in other designated burial areas. Hazardous wastes are shipped to approved disposal sites off the ORR or are stored on-site. Radioactive solid wastes are managed on-site and placed either in retrievable storage units or in disposal units, depending on the type and quantity of radioactive material present.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques before they are released to the atmosphere.

Liquid radioactive wastes are not released but are contained in tanks for ultimate disposal. After treatment, process water is discharged under National Pollutant Discharge Elimination System (NPDES) permits to White Oak Creek, Poplar Creek, and upper East Fork Poplar Creek, which are small tributaries of the Clinch River.

1.2 REGIONAL DEMOGRAPHY

Except for the city of Oak Ridge, the land within 8 km (5 miles) of the ORR is predominantly rural, used largely for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are favorite recreational activities in the area. The approximate location and population (1980 census data) of the towns nearest the ORR are Oliver Springs (pop. 3600), 11 km (6.8 miles) to the northwest; Clinton (pop. 5200), 16 km (10 miles) to the northeast; Lenoir City (pop. 5400), 11 km (6.8 miles) to the southeast; Kingston (pop. 4400), 11 km (6.8 miles) to the southwest; and Harriman (pop. 8300), 13 km (8 miles) to the west. Figure 1.6 shows the locations of these towns. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km (25 miles) to the east and has a population of approximately 183,000. Table 1.2 in Vol. 2 lists cities and population centers within an 80-km (50-mile) radius of the ORR. Directional 80-km-radius population distribution maps are shown in Figs. 1.7 and 1.8. It should be noted that the center of these figures is the center of the ORR and that most of the area within a 10-km (6.2-mile) radius is part of the ORR. Fewer than 5000 people live within 10 km of the ORR center. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar reservoirs on the Clinch River form the southern, eastern, and western boundaries of the ORR, and the residential sector of Oak Ridge forms the northern boundary. The ORR is within the Oak Ridge city limits.

1.3 GEOLOGY

The geologic and associated topographic characteristics of the ORR affect air and water flow and stability of emplaced wastes. The ORR is located in the Tennessee section of the Valley and Ridge Province, which is part of the Southern Appalachian

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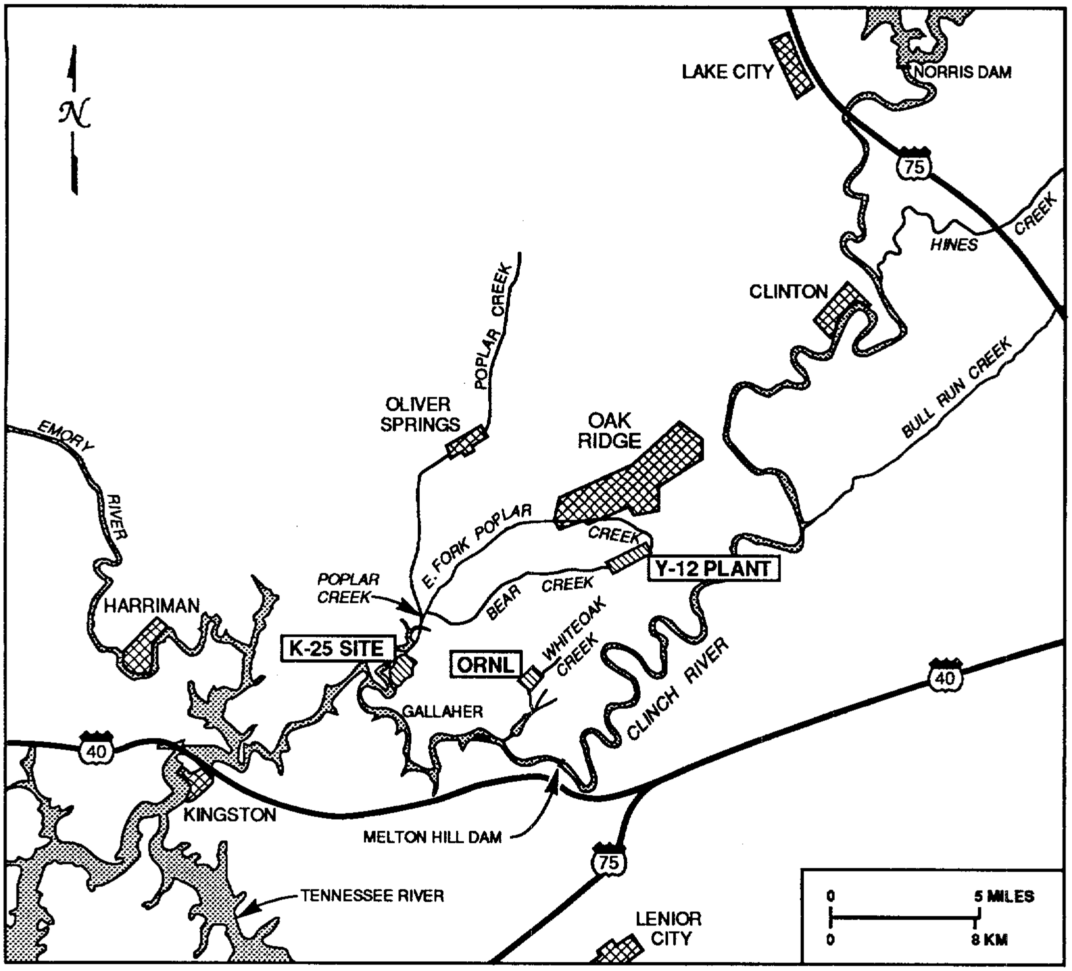

Fig. 1.6. Location map of towns nearest the ORR.

fold and thrust belt [Fig. 1.9 (and Fig. 1.1 in Vol. 2)]. The area is characterized by a succession of northeast-trending thrust faults that structurally stack and replicate the Paleozoic rocks of this area (Fig. 1.10; Fig. 1.11; and Fig. 1.2 in Vol. 2). As a result of thrusting and subsequent differential erosion, a series of valleys and ridges have formed that parallel the thrust faults. In general, the more-resistant siltstone, sandstone, and dolomite units are ridge-formers, and the less-resistant shales and shale-rich carbonates underlie the valleys of the region.

1.3.1 Stratigraphy

The stratigraphy of the area, in ascending order, includes the Lower Cambrian Rome Formation, the Cambrian Conasauga Group, the Cambro-Ordovician Knox Group, and the Middle Ordovician Chickamauga Group. Younger Upper Ordovician to Mississipian rocks are exposed locally in the cores of two synclines north of the White Oak Mountain Thrust Fault (Fig. 1.10). (Refer to Appendix A for further description.)

1.3.2 Structure

The ORR is located in a foreland fold and thrust belt. As a result, its geology is strongly influenced by structural features at all scales, including regional thrust faults, local thrust faults and tear faults, local folding of relatively weak units, and widespread fracture development. The large-scale structures that were formed during the Permian-Pennsylvanian Alleghanian Orogeny have not been historically active. Although fracture formation has occurred at times from the Ordovician (from burial processes) to

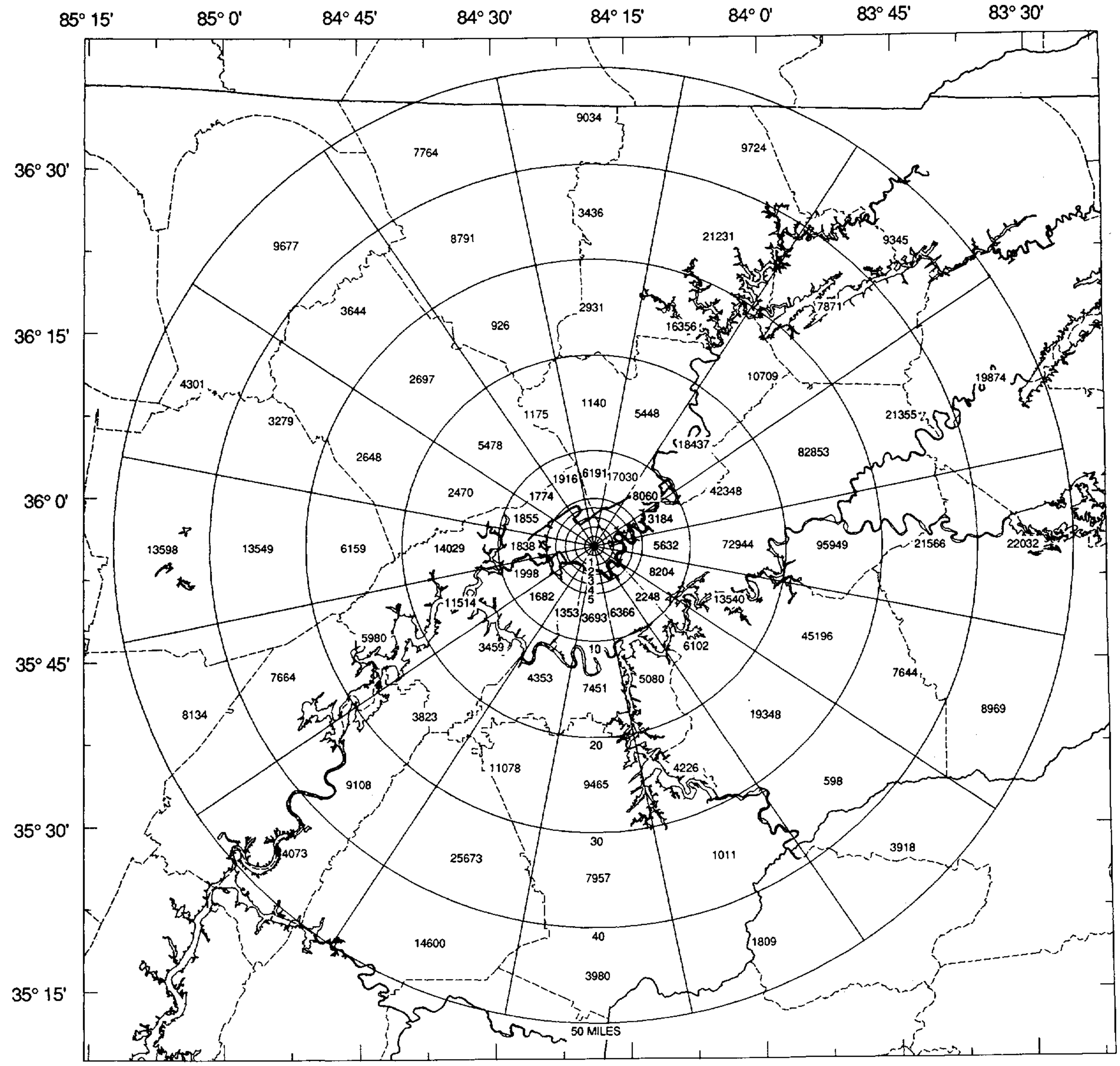

Fig. 1.7. Projected 1990 population by sector from the center of the Oak Ridge Reservation, based on 1980 census data.

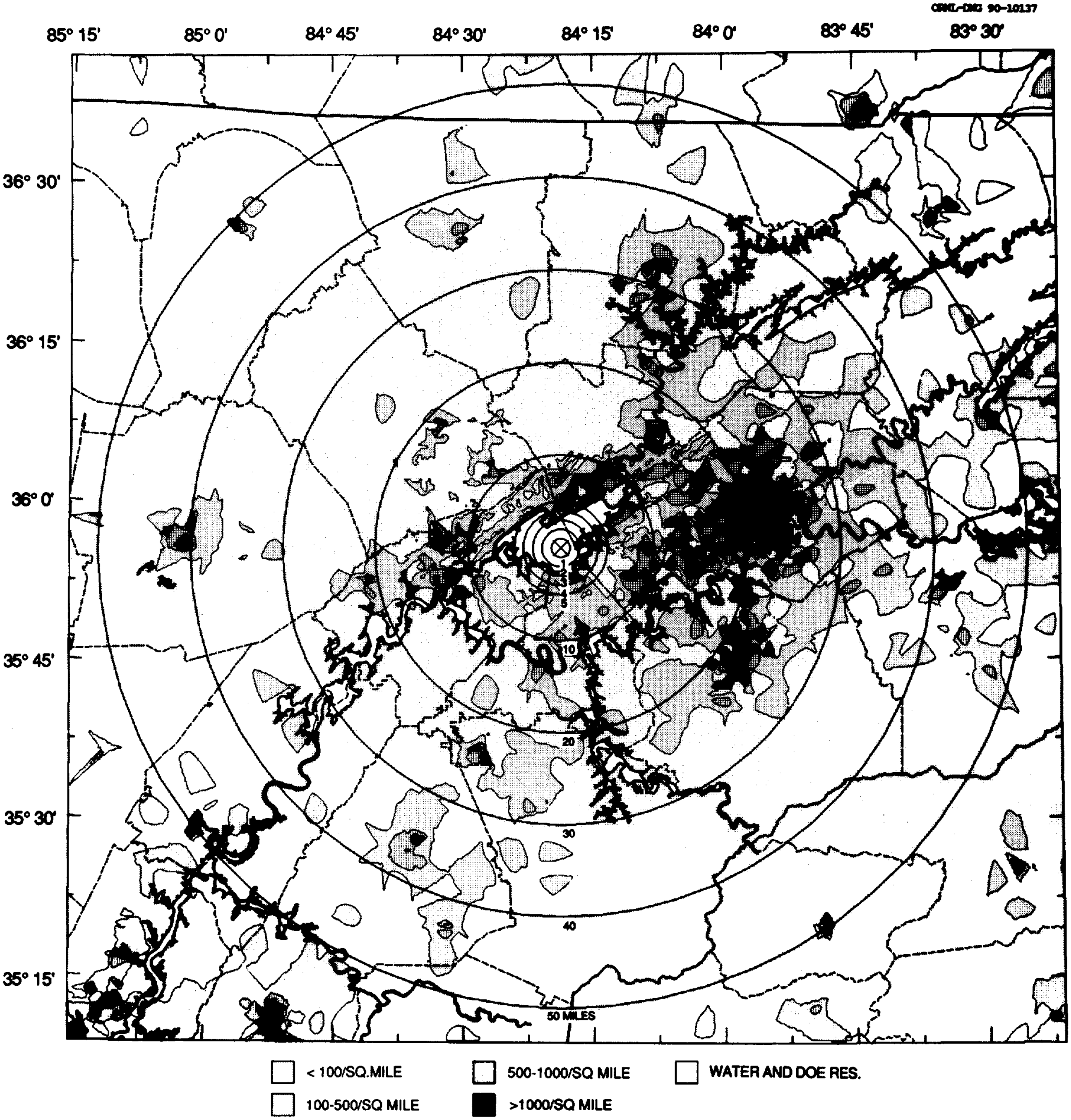

Fig. 1.8. Projected 1990 population densities by 10-km (6.2-miles) section of East Tennessee area, based on 1980 census data.

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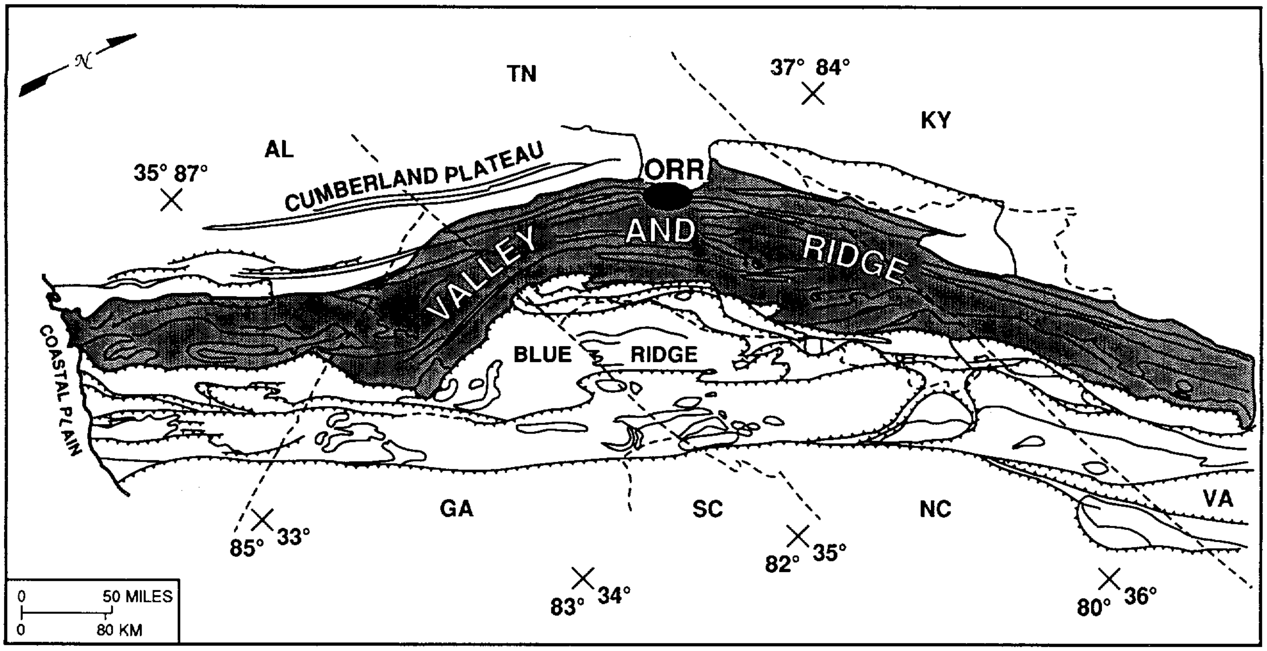

Fig. 1.9. Geology of the Southern Appalachians.

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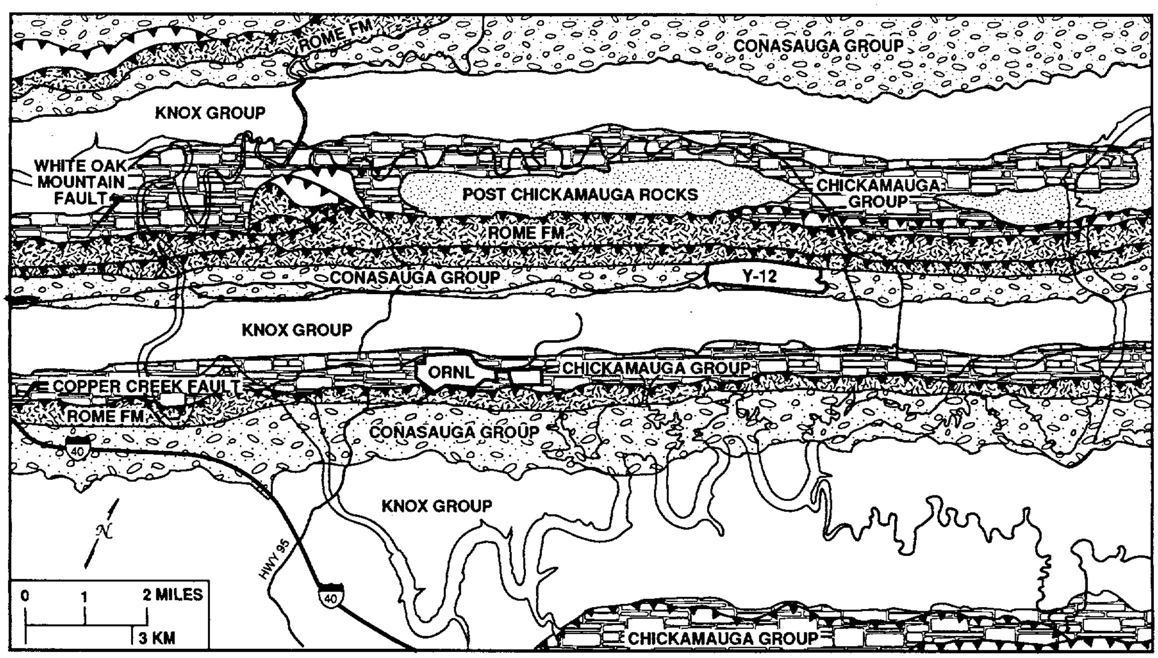

Fig. 1.10. Geologic map of the Oak Ridge Reservation.

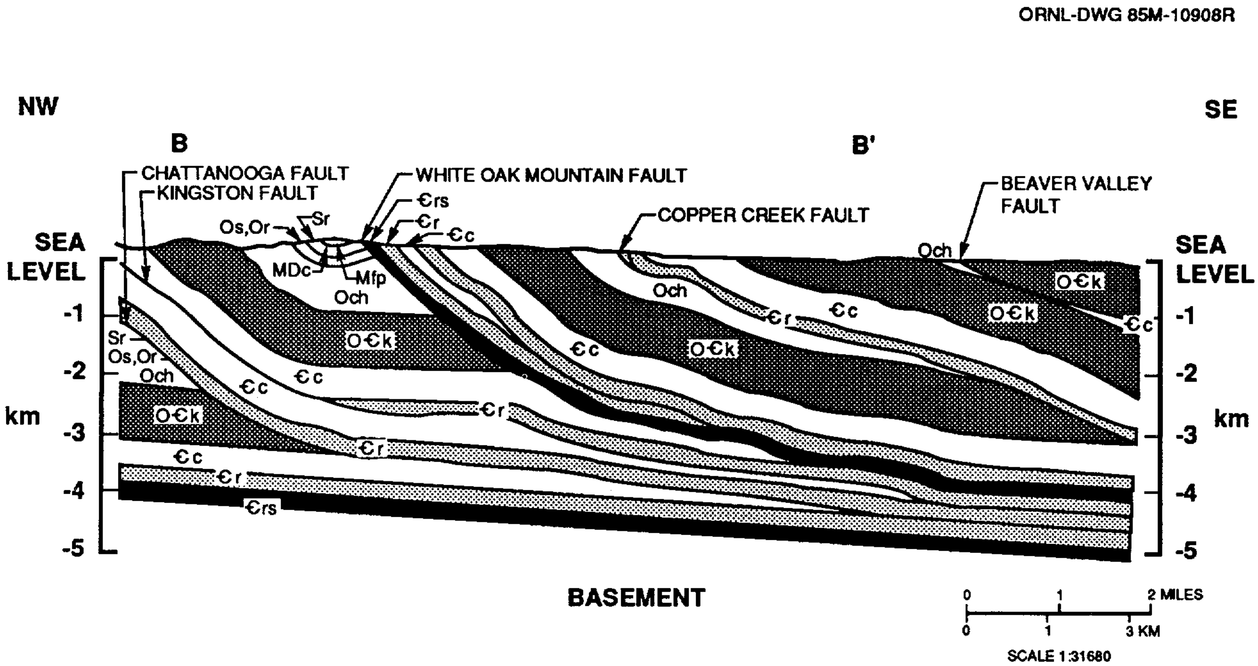

Fig. 1.11. Geologic cross-section of the Oak Ridge Reservation.

the present (from erosion and unroofing processes), the Alleghanian Orogeny was probably the strongest influence on fracture formation. (Refer to Appendix A for further description.)

1.4 SURFACE WATER

Potable water from most nonrural areas comes from surface water. This section includes discussions of stream classification, surface water hydrology, watershed characteristics, and water use.

1.4.1 Stream Classification

The Clinch River is the major surface water source that receives discharges from the Oak Ridge installations. Four TVA reservoirs influence the flow and/or water levels of the lower Clinch: Norris and Melton Hill on the Clinch River and Watts Bar and Fort Loudon on the Tennessee River.

The area on and around the ORR has no streams classified as wild and scenic rivers. Most of the streams on the ORR are classified for fish and aquatic life, irrigation, and livestock watering and wildlife. Table 1.3 in Vol. 2 gives the State of Tennessee stream use classifications for the Clinch River and its tributaries on or near the ORR. Classifications are based on water quality, designated uses, and resident aquatic biota. For each designated water-use classification, specific water quality criteria are applied.

1.4.2 Surface Water Hydrology

Figure 1.12 shows the location of surface water bodies in the vicinity of the ORR. The ORR is bounded on the south and west by a 63-km stretch of the Clinch River. Melton Hill Dam is located at Clinch River kilometer (CRK) 37.2 (river mile 23), forming the Melton Hill Reservoir. Several major embayments bound the ORR; the largest is the Bearden Creek embayment, with an approximate surface area of 48 ha (120 acres). Other embayments include Walker Branch, McCoy Branch, and Scarboro Creek.

Both groundwater and surface water are drained from the ORR by a network of small tributaries of the Clinch River, as shown in Fig. 1.12. At Kingston, Tennessee, the Clinch flows into the Tennessee River, which is the seventh largest river in the United States. Water levels in the Clinch River in the vicinity of the ORR are regulated by TVA, and fluctuations of the river have an impact on the tributary streams draining the ORR.

Each of the three DOE facilities affects a different subbasin of the Clinch River. Drainage from the Y-12 Plant enters both Bear Creek and East Fork Poplar Creek; the K-25 Site drains predominantly into Poplar Creek and Mitchell Branch; and ORNL drains into White Oak Creek and several tributaries.

1.4.3 Watershed Characteristics

The Clinch River has its headwaters near Tazewell, Virginia, and empties into the Tennessee River near Kingston, Tennessee, at Tennessee River kilometer (TRK) 914 (river mile 568). The Clinch watershed comprises about 11% of the Tennessee River watershed. Three dams operated by TVA control the flow of the Clinch River. Norris Dam, constructed in 1936, is approximately 50 km (31 miles) upstream from the ORR. Melton Hill Dam, completed in 1963, controls the flow of the river near the ORR. Its primary function is power generation (Boyle et al. 1982). Watts Bar Dam is on the Tennessee River near the lower end of the Clinch.

1.4.4 Water Use

Nine public water supply systems, which serve about 91,500 people, withdraw surface water within a 32-km (20-mile) radius of the ORR. Of these nine supply systems, only the city of Kingston and the K-25 Site Water Treatment Plant are downstream of the ORR. The intake for Kingston is located at TRK 914.2 (river mile 566.8), about 0.6 km (0.37 mile) above the confluence of the Clinch and Tennessee rivers and 34.1 km (21.1 miles) below the mouth of Poplar Creek. (This location is monitored because it is in the area of backflow of Clinch River water in the Tennessee.) Kingston withdraws approximately 9% of its average daily supply from the Tennessee River. The K-25 Site Water Treatment Plant intake is located 4 km (2.5 mi) above the mouth of Poplar Creek and provides all of the water for the K-25 Site.

1.5 GROUNDWATER

Groundwater in the Tennessee Valley region supplies water to many rural residences, industries,

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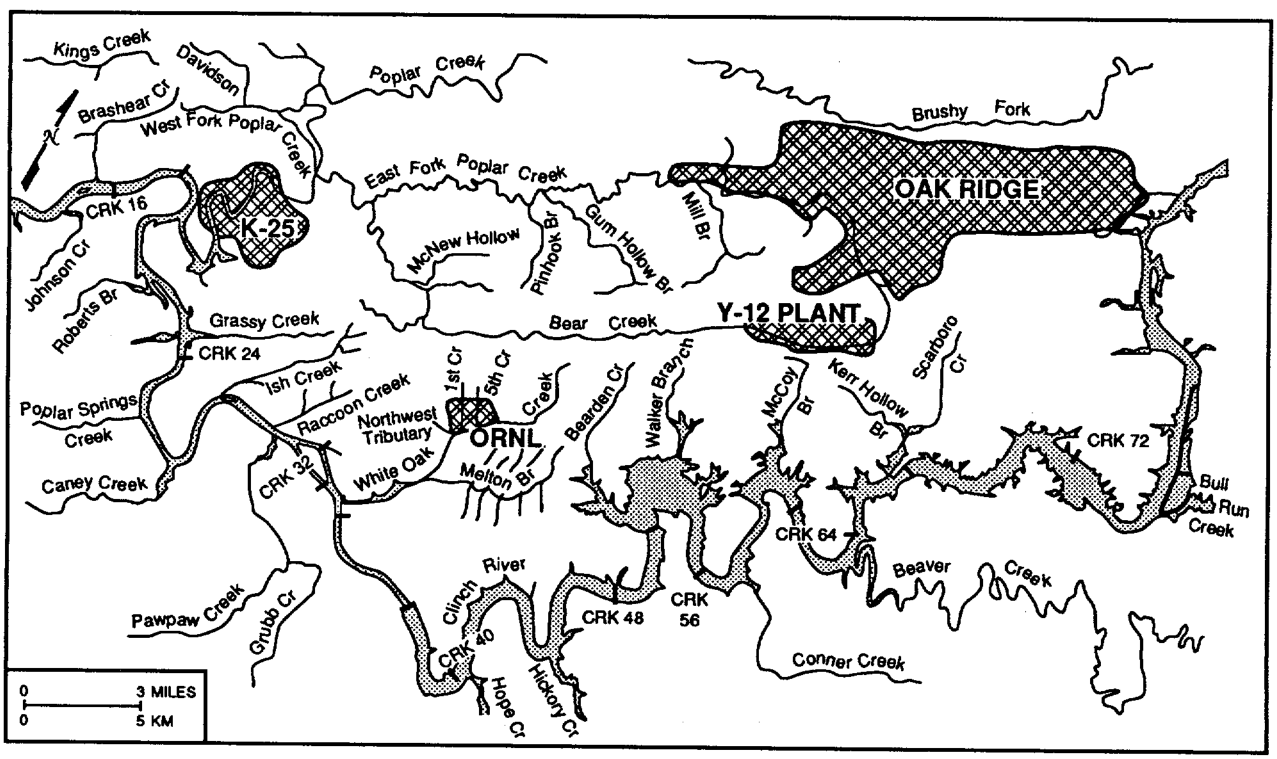

Fig. 1.12. Location map of Oak Ridge Reservation tributaries.

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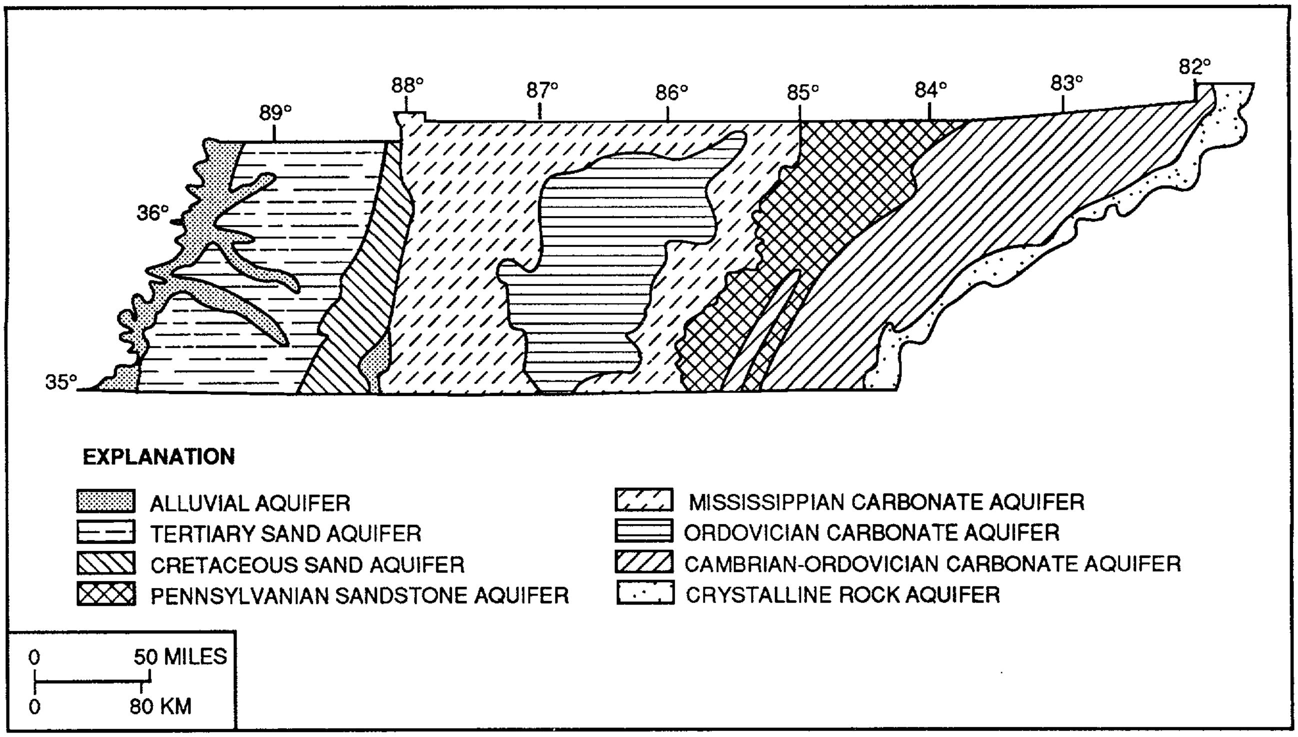

Fig. 1.13. Principal aquifers in Tennessee.

and public water supplies and sustains base flow in streams and rivers. Most farm use is for livestock watering and washing. This section includes discussion of groundwater occurrence in the region and local groundwater use.

1.5.1 Geohydrology and Groundwater Occurrence

In the Valley and Ridge Province of Tennessee, groundwater occurs in bedrock, in the regolith, and in a few alluvial aquifers along the largest rivers. Groundwater flow in the shale and carbonate rock that dominate the region's bedrock occurs in fractures and solution cavities.

1.5.2 Groundwater Use

The objective of groundwater classification is to provide a systematic approach for designating the use of and water quality goal for the groundwater resource. More than 50% of the population of Tennessee relies on groundwater for drinking water supplies (Henry et al. 1986). Twenty-one percent of water used in the state (exclusive of thermoelectric use) is groundwater. Of this, about 55% is withdrawn for public and domestic supplies, 42% for self-supplied industrial use, and 1% for irrigation (Bradley and Hollyday 1985; Henry et al. 1986). Nine principal aquifers have been identified in Tennessee, as illustrated in Fig. 1.13. The major portion of the industrial and drinking water supply in the Oak Ridge area is taken from surface water sources. However, single-family wells are common in adjacent rural areas not served by public water supply systems. As in most of East Tennessee, usable groundwater on the ORR and in areas adjacent to the ORR occurs primarily in solution cavities or in fractures in the rocks. Other than those adjacent to the city of Oak Ridge, most of the residential wells in the immediate area are south of the Clinch River.

1.6 CLIMATE AND ATMOSPHERIC PROCESSES

Oak Ridge has a temperate climate with warm, humid summers and cool winters. No extreme conditions prevail in temperature, precipitation, or winds. Spring and fall are usually long, and the weather is normally sunny with mild temperatures. Severe storms such as tornadoes or high-velocity winds are rare. The mountains frequently divert hot, southeasterly winds that develop along the southern Atlantic coast away from this region.

Oak Ridge is one of the country's calmest wind areas. Because of this, providing relief from the summer's humidity through ventilation is difficult. The atmosphere can be considered to be in an inversion status about 36% of the time. The daily up- and down-valley winds, however, provide some diurnal exchange. The prevailing wind directions are northeasterly (up-valley) and southwesterly (down-valley).

1.7 PRECIPITATION

Precipitation varies both within and between years, as shown in Fig. 1.14. The 40-year annual average precipitation (water equivalent) is 1.37 m (53.75 in.), including approximately 0.26 m (10.4 in.) of snowfall, with monthly precipitation peaking in January and February. Winter storms are generally of low intensity and long duration. Another peak in rainfall occurs in July when short, heavy rains associated with thunderstorms are common. Typically in October, slow-moving high-pressure cells suppress rain and, while remaining nearly stationary for many days, provide mild, clear, dry weather. Poor air dilution (and thus the primary air pollution episodes) occurs with the greatest frequency and severity during this period. Precipitation in 1990 was 1.52 m (59.78 in.), about 0.15 m (5.8 in.) above the annual average.

1.8 ENVIRONMENTAL MONITORING

Published environmental summary reports for the DOE ORR have been issued for each year since 1971. The current environmental program is designed primarily to meet various regulatory requirements and DOE directives and to provide a continuity of data on environmental media at unregulated locations. The federal legislative framework that establishes

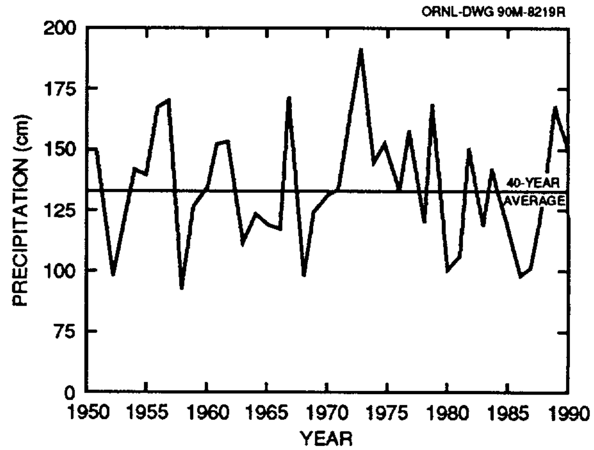

Fig. 1.14. Annual precipitation history of the Oak Ridge area.

standards and regulates environmental releases consists mainly of the following: Clean Air Act (CAA); Clean Water Act (CWA); Safe Drinking Water Act (SDWA); Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as "Superfund"; Resource Conservation and Recovery Act (RCRA); TSCA; SARA; the Atomic Energy Act (AEA); and Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Administrative bodies principally concerned with implementation and enforcement on the federal level are the U.S. Environmental Protection Agency (EPA) and DOE and, on the state level, TDC.

Environmental monitoring consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the collection and analysis of samples, or measurements of liquid and gaseous effluents. Environmental surveillance is the collection and analysis of samples, or direct measurements, of air, water, soil, foodstuff, biota, and other media from DOE sites and their environs. Environmental monitoring is performed by each site for the purpose of characterizing and quantifying contaminants, assessing radiation exposures of members of the public, demonstrating compliance with applicable standards and permit requirements, and assessing the effects, if any, on the local environment.

The samples are analyzed for various radioactive, physical, and chemical parameters. In some cases, such as liquid effluent outfalls, the discharge permit may require the analysis of up to 20 different parameters.

Annual summaries are presented in the following sections for each of the media sampled. The summary tables generally give the number of samples collected and the maximum, minimum, average, and standard error of the mean (SE) values of parameters for which determinations were made. This value is based on multiple samples collected throughout the year. It includes the random uncertainty over time and space associated with sampling, analysis, and the intrinsic variability of media. The random uncertainty is a statement of precision (or imprecision), a measure of the reproducibility or scatter in a set of successive measurements, and an indication of the stability of the average value for a parameter. When differences in the magnitudes of the observations are small, the SE is small, and the precision is said to be high; when the differences are large, the SE is large, and the precision is low. Random uncertainties are assessed and propagated by statistical methods (see Appendix B for calculations). Average values have been compared where possible with applicable guidelines, criteria, or standards as a means of evaluating the impact of effluent releases or environmental concentrations.

In some of the tables, radionuclide concentrations are compared with derived concentration guides (DCGs) as published in DOE Order 5400.5. These concentration guides were established for the drinking water pathway and the inhalation pathway and are guidelines for the protection of the public. DOE Order 5400.5 defines a DCG as the concentration of a radionuclide in air or water from which, under conditions of continuous exposure by one exposure pathway (i.e., drinking water, inhaling air, submersion) for 1 year, a "reference person" would receive an effective dose equivalent of 100 mrem. A reference person is a hypothetical human who is assumed to inhale 8400 m^3 (296,700 ft^3) of air in a year and to drink 730 L (190 gal) of water in a year. When there are multiple DCGs for a given isotope, the most restrictive value is used. When the percent of the DCG is less than 0.010, the percent is reported as less than 0.01. When total radioactive Sr is measured, it is compared to the DCG for ^{90}Sr, which is the most restrictive value.

The current convention for radioactivity data at the instrument detection limit is to treat it in the same manner as instrument responses above the detection limit. The instrument background is subtracted from the actual instrument signal, and the result is reported. Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and get a negative number. The advantage to this approach is that no bias is introduced in calculating statistical summaries of the data.

Measurements of nonradioactive analytes at or below the instrument detection limit are expressed as "less than" (<) the detection limit value. In computing summary statistics, the less than results are assigned the detection limit value. When a statistic includes one or more "less than" results, the computed value is also expressed as a less than quantity.

AIRBORNE DISCHARGES, AMBIENT AIR MONITORING, METEOROLOGICAL MONITORING, AND EXTERNAL GAMMA RADIATION

2. AIRBORNE DISCHARGES, AMBIENT AIR MONITORING, METEOROLOGICAL MONITORING, AND EXTERNAL GAMMA RADIATION

The DOE Oak Ridge facilities are subject to regulations issued by the TDC Air Pollution Control Board, the EPA, and DOE Orders. Nonradioactive emission sources are regulated by TDC, and radioactive emission sources are regulated by EPA under the National Emission Standards for Hazardous Air Pollutants (NESHAP). The authority for these regulations is derived from the Clean Air Act and the Tennessee Air Quality Control Act.

The TDC air pollution control rules regulate pollution sources to protect the public health and welfare and the environment. These rules include regulations for maximum allowable ambient air concentrations of certain pollutants, open burning, pollution sources such as coal-fired boilers and processes, fugitive emission sources, performance standards for new sources, and hazardous air pollutants. State-issued permits are required for air pollution sources with the exception of certain very small emission sources, which are specifically exempt from permit requirements.

The rules for radioactive emission sources, issued by EPA, limit the amount of exposure to radioactivity to the nearest or the most affected member of the public. EPA sets the limit on exposure to radioactivity by first determining a safe exposure level and then adding a margin of safety. The most affected member of the public is determined by EPA-approved radioactive emissions dose modeling. The NESHAP rules were reissued in December 1989, and efforts are continuing to secure EPA approval of strategies for compliance with these new requirements for the Oak Ridge facilities.

DOE regulations governing airborne emissions are established in DOE Orders 5400.1 and 5400.5, and supplementary guidance is provided in Regulatory Guide 5400.6.

2.1 AIRBORNE DISCHARGES

Each facility has a comprehensive air pollution control and monitoring program to ensure that airborne discharges meet regulatory requirements and do not adversely affect ambient air quality. Air pollution controls at the three Oak Ridge facilities include exhaust gas scrubbers, baghouses, and exhaust filtration systems designed to remove airborne pollution from the exhaust gases before release to the atmosphere. Process modifications and material substitutions are also made in an effort to minimize air emissions. In addition, administrative controls play a role in regulating emissions. Each installation has developed a stack monitoring program to measure pollutants that are not removed by the air pollution control equipment. Ambient air monitoring is also conducted around the facilities and within the surrounding East Tennessee communities to assess the impacts of operations within the three Oak Ridge facilities on the ambient air quality of the region.

The following three sections describe airborne pollutants emitted from the Oak Ridge facilities during 1990. These sections also describe the emissions monitoring performed at each facility and present data on measured pollutant concentrations within the surrounding communities. A brief section is also included on meteorological measurements conducted during 1990 at each facility. A discussion of atmospheric dispersion modeling and atmospheric radiological dose modeling is included in Sect. 7.

2.1.1 Oak Ridge Y-12 Plant

Description

The release of contaminants into the atmosphere at the Oak Ridge Y-12 Plant occurs almost exclusively as a result of plant production, maintenance and waste management operations, and steam generation. Most process operations are served by process ventilation systems that remove air contaminants from the workplace. More than 500 of these are permitted (Table 2.11, Vol. 2). Approximately 85 of these exhaust systems serve areas where depleted or enriched uranium is processed, and these are monitored continuously for radioactive emissions. Additionally, there are several hundred room air ventilation systems in plant buildings. These systems are typically not significant emission points for air pollutants because room air pollution concentrations are kept very low.

As illustrated in Figs. 2.1 and 2.2, atmospheric discharges from Y-12 Plant production operations are minimized through the extensive use of air pollution control equipment. High-efficiency particulate air (HEPA) filters are used to essentially eliminate particulate emissions (including uranium) from numerous production shops. HEPA filters remove more than 99% of the particulates from the exhaust gases. Exhaust gas scrubbers, baghouses, and other emission control equipment are used to reduce airborne discharges of other pollutants. Although Y-12 Plant airborne discharges are within regulatory guidelines, improvements continue to be made to the plant's exhaust ventilation systems to further reduce emissions. While many of these improvements involve the installation of new air pollution control equipment, material substitution, and process modification, projects are also being examined and implemented to reduce plant emissions and to comply with waste minimization strategies currently being pursued by plant operations.

Summary

Y-12 Plant radiological emission estimates are further broken down in Table 2.1. Y-12 Plant uranium stack emission totals were made using stack sampling data obtained from sampling equipment installed in March 1987 under the Stack Radiological Monitoring Project. Uranium stack losses are continuously measured on 85 process exhaust stacks by extracting a representative sample of stack gas through a multipoint sampling probe. Particulate matter (including uranium) is removed from the stack sample through filtration by a 47-mm-diam filter paper. Sample filter papers are changed routinely at each location an average of three times per week and analyzed in the Y-12 Plant laboratory to determine uranium stack emissions.

Engineering analysis was also used to obtain a conservative estimate of uranium emissions into the atmosphere from room exhaust ventilation systems within the plant. These emission estimates are included in plant uranium emission totals listed in Table 2.1.

Table 2.1. 1990 Y-12 Plant airborne uranium emissions estimates[a]

Source of emissions	Quantity emitted (kg)	Quantity emitted (Ci)
Enriched uranium process exhaust	1.2	0.064
Depleted uranium process exhaust	4.3	0.002
Enriched uranium room exhaust	0.1	0.007
Depleted uranium room exhaust	15.3	0.008
Total	20.9	0.081

[a]See Table 7.2 for off-site committed dose equivalents resulting from Y-12 Plant uranium emissions.

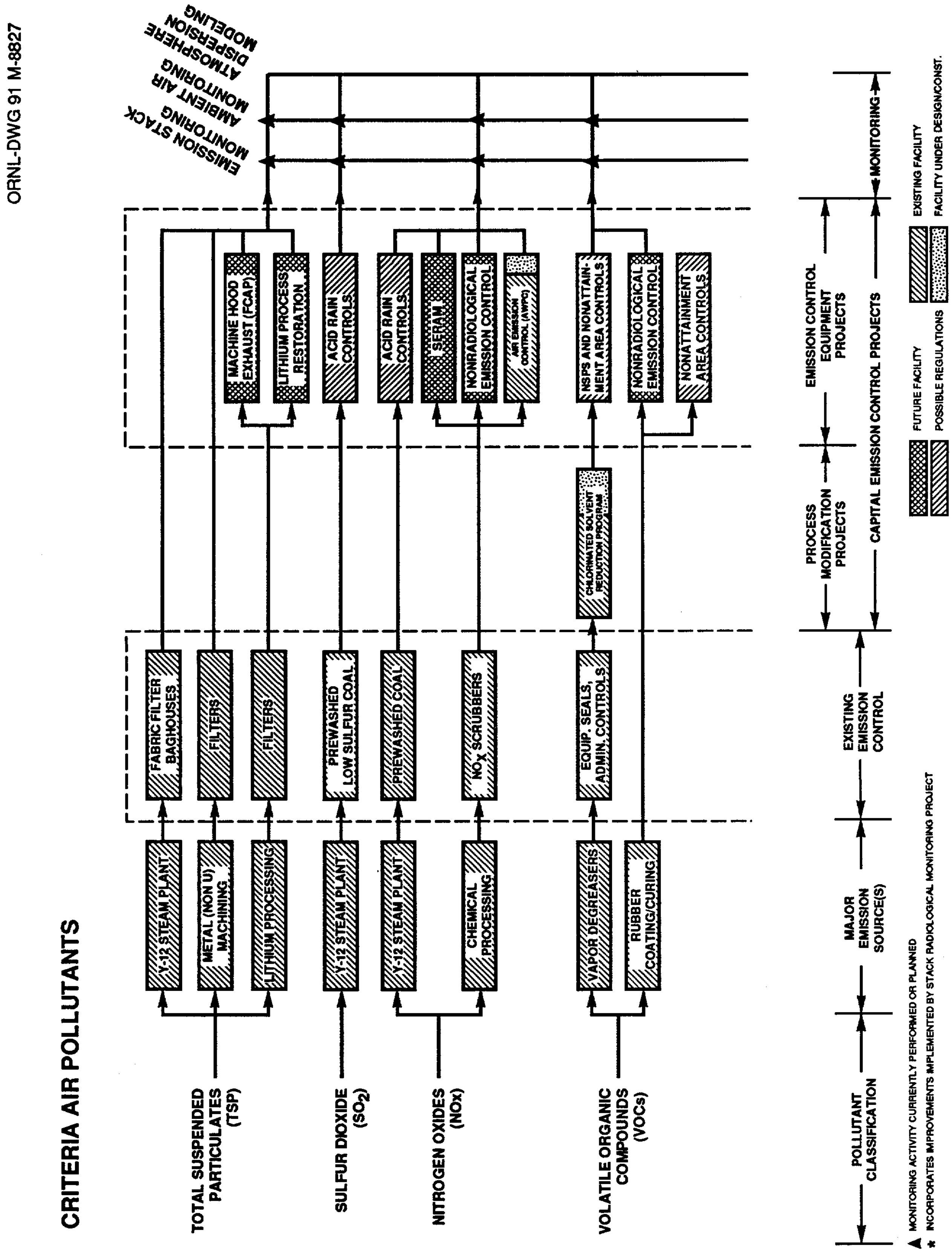

Fig. 2.1. Air pollution control program at the Y-12 Plant (criteria air pollutants).

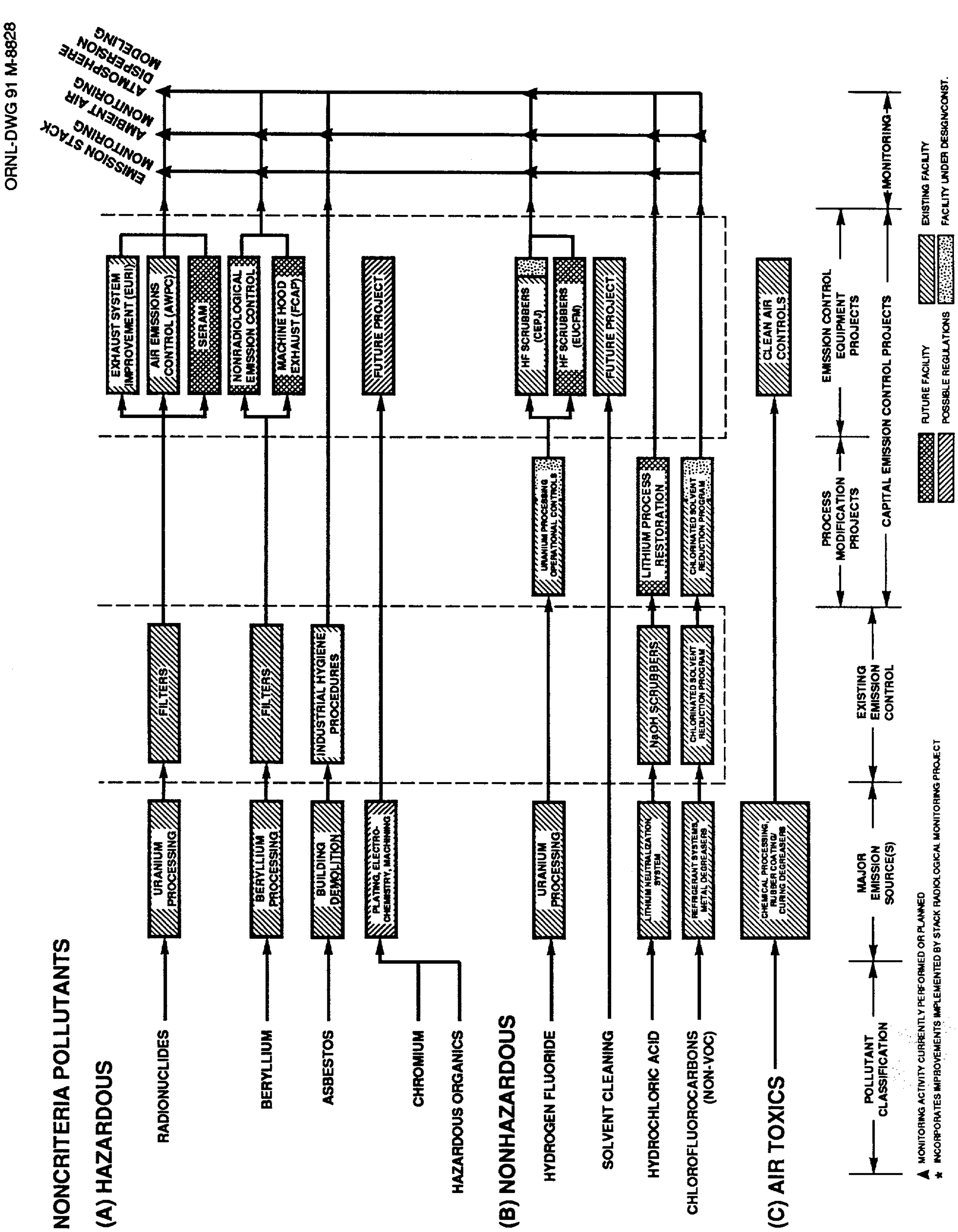

Fig. 2.2. Air pollution control program at the Y-12 Plant (noncriteria air pollutants).

In 1988 a study was conducted to better estimate depleted uranium emissions through unmonitored room exhaust ventilation systems. This study took into account the current information on ventilation systems and Health Physics data from the depleted uranium processing areas. The room exhaust uranium emissions for 1990 have been updated using that year's Health Physics data and additional information on exhaust areas revealed in the environmental survey recently conducted at the Y-12 Plant. The survey identified some enriched uranium area exhaust, and the results have been included for 1990. Radionuclides other than uranium are handled in millicurie quantities as a part of ORNL research activities at facilities in the Y-12 Plant. The releases from these activities are minimal and have a negligible impact on the total Y-12 Plant dose; therefore, only Y-12 Plant uranium discharges are shown in Table 2.1.

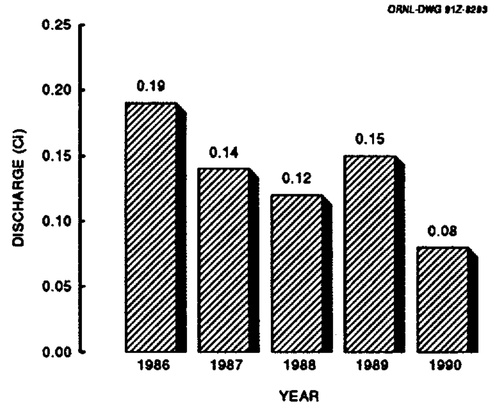

Fig. 2.3. Total curie discharges of uranium from the Y-12 Plant to the atmosphere, 1986–1990.

Chemical emissions

Emission estimates have been made for a number of major pollutant categories. These are itemized in Appendix C (see Table C.1), which addresses chemical releases and SARA Title III, Section 313.

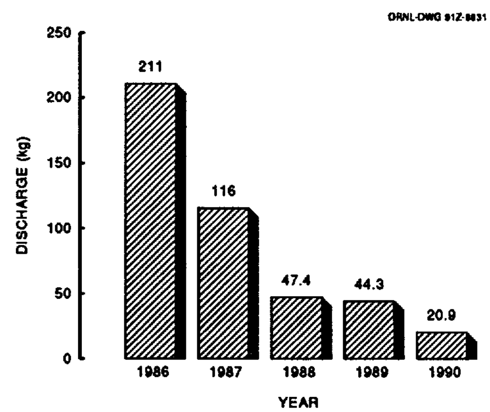

Fig. 2.4. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1986–1990.

Discussion

It is estimated that a total of 0.081 Ci (20.9 kg) of uranium was released into the atmosphere in 1990 as a result of Y-12 Plant processing operations (Figs. 2.3 and 2.4). Because of the significantly higher specific activity of enriched uranium over that of depleted uranium, approximately 88% of the curie release was from emissions of enriched uranium particulates, whereas only 6% of the total mass of uranium released was from enriched uranium losses.

As illustrated in Fig. 2.4, 1990 Y-12 Plant uranium emissions estimates were lower than in recent years. This reduction was in part the result of improvements made during 1987 in uranium emissions monitoring and the installation of new exhaust gas filtration systems in 1987 and 1988, especially in the depleted uranium areas of the plant. In 1989 and 1990, the reductions were primarily the result of improved administrative controls, including better testing and changeout procedures for process filters and closer control of the procedures themselves. The further reduction in 1990 also reflects recent improvements in contamination control throughout the Y-12 Plant, as reflected in the room exhaust estimates from Health Physics data. Twenty-seven stacks with the greatest potential to emit significant amounts of uranium are equipped with "breakthrough monitors." These monitors measure the rate of increase of radiation on the trapping media and alert operations personnel if filtration system efficiencies decline.

2.1.2 Oak Ridge National Laboratory

Description

The major gaseous emission point sources for ORNL consist of the following eight stacks located in Bethel and Melton valleys (Fig. 2.5):

Building	Description
2026	High Radiation Level Analytical Laboratory
3020	Radiochemical Processing Plant
3039	3500 and 4500 areas cell ventilation system Central off-gas and scrubber system Isotope solid state ventilation system 3025 and 3026 areas cell ventilation system
7025	Tritium Target Fabrication Facility
7830	Melton Valley Storage Tank Facility
7911	Melton Valley complex (High Flux Isotope Reactor, Radiochemical Engineering Development Center)
7512	Molten Salt Reactor Facility Project
6010	Electron Linear Accelerator Facility

Discharges from each stack are unique because of the wide variety of research activities performed at ORNL. Radiological gaseous emissions from ORNL typically consist of solid particulates, adsorbable gases (e.g., iodine), tritium, and nonadsorbable gases.

Gaseous waste streams at ORNL consist mainly of ventilation air from contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. Many sources, mostly nonradioactive, are permitted with the TDC Air Pollution Control Board. A list of air permits issued by TDC for emission sources at ORNL is presented in Table 2.12 of Vol. 2. All gaseous emissions are treated and filtered before discharge to the atmosphere. Typically, contaminated and potentially contaminated gaseous wastes are treated, then filtered with HEPA and charcoal filters before discharge to ensure that any radioactivity released is within acceptable levels.

Airborne emissions sampling

Each of the eight major point sources is provided with a variety of surveillance instrumentation, including radiation alarms, near-real-time monitors, and continuous sample collectors. Only data resulting from analysis of the continuous samples are used in this report. The other equipment does not provide data of sufficient accuracy and precision to support the quantitation of emission source terms. The single exception is for noble gases, which must be evaluated with a monitoring chamber because those radionuclides cannot be quantitatively captured on a sampling medium.

Data are presented for all areas except the Electron Linear Accelerator Facility (Building 6010), where continuous sampling equipment is not presently installed. The Electron Linear Accelerator Facility exhibits extremely low concentrations of very short half-lived isotopes. Consequently, this stack has virtually no impact on the radiation dose associated with the operation of ORNL.

The sampling systems generally consist of in-stack sampling probes, sample transport piping, a particulate filter, an activated charcoal canister, a silica-gel tritium trap, flow measurement and totalizing instruments, a sampling pump, and return piping to the stack. The sampling system for the Tritium Target Fabrication Facility is configured with a tritium trap only. The sampling systems at 2026, 3020, and 7512 do not have tritium traps.

Data sources for the various isotopes identified in the 1990 airborne emission source term are shown in Table 2.2 and are further discussed in the summary. Tritium data were generated by inventory for 3039 and by sampling for 7911 and 7025. Consequently, there is a double entry for tritium in the table. Other double entries are for isotopes that were captured by more than one sampling medium.

Summary

The 1990 radioactive airborne emissions data included 26 isotopes and 4 gross parameters captured from 5 data sources. Table 2.2 provides a listing of isotopes and gross parameters and the media from which they were captured.

The charcoal filters, particulate filters, and silica-gel traps (as described above) were collected weekly. During 1990, the weekly tritium samples were composited biweekly for analysis. The 3039 area is sampled in each of the four main ducts feeding into the 3039 stack, resulting in four sets of data for that stack. For the purposes of this report, the 3039 area data were weighted proportionally according to each duct's contribution to the total stack flow and summed.

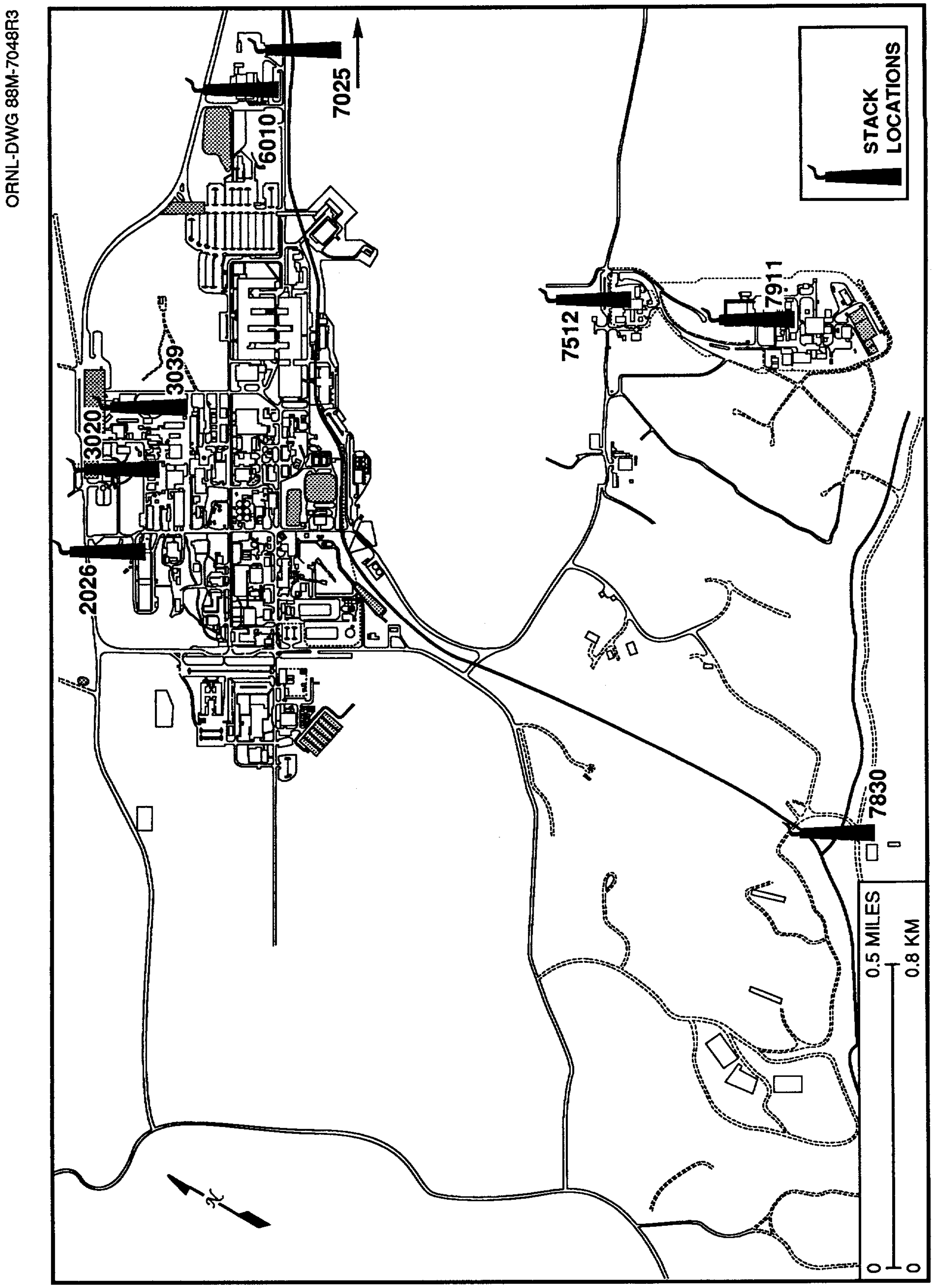

Fig. 2.5. Locations of major stacks (emission points) at ORNL.

Table 2.2. Data sources for airborne radioactive emissions from ORNL, 1990

Radionuclide	Charcoal filter	Weekly particulate filter	Particulate filter composite	Monitoring or inventory	Silica gel
^{194}Au	X				
^{7}Be			X		
^{82}Br	X				
^{60}Co	X		X		
^{134}Cs			X		
^{137}Cs	X		X		
^{154}Eu			X		
^{155}Eu			X		
Gross alpha		X			
Gross beta		X			
^{3}H				X	X
^{129}I	X				
^{131}I	X		X		
^{132}I	X				
^{133}I	X				
^{135}I	X				
^{140}La			X		
Noble gas				X	
^{191}Os	X		X		
^{212}Pb	X				
^{238}Pu			X		
^{239}Pu			X		
^{106}Ru	X				
^{75}Se	X				
Total Sr			X		
^{132}Te	X				
^{228}Th			X		
^{230}Th			X		
^{232}Th			X		
Total U			X		

Charcoal filters are a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples identified nine additional noniodine isotopes, as shown in Table 2.2.

Particulate filters were held for 8 days prior to analysis to minimize the contribution from short-lived isotopes. A study conducted during 1989 and 1990 (Tardiff and Wolf, 1991) showed the short-lived gross alpha and gross beta signature of the stacks to be primarily associated with ^{220}Rn and its daughter products. This decay series is quantified through measurements of ^{212}Pb on the activated charcoal filter. If the short-lived gross alpha and beta were included, the emissions of ^{220}Rn and its daughters would be counted twice. The particulate filters are analyzed for gross alpha and gross beta because radioactive particulates are typically alpha and beta emitters. These gross measurements are not used in dose calculations because an assumption about the contributing isotope would be necessary. Instead, the particulate filters are composited quarterly and analyzed for alpha- and beta-emitting isotopes, and these data are used for dose assessment.

Compositing provides an opportunity to evaluate the radionuclides with lower specific activity. Identification and quantification of this group is initially confounded by the presence of short-lived isotopes.

Noble gas emissions from stacks 3039 and 7911 were derived from real-time monitoring data. Noble gases are chemically inert and, consequently, cannot be trapped on a collecting medium for analysis. Instead, after the monitoring system gas stream has passed through the particulate filter and the charcoal filter, a part of the stream is pumped through a lead-shielded chamber that is equipped with a beta-gamma detecting monitor. The implicit assumption is that the upstream collecting media have removed all but the noble gases. The noble gas monitor data are accrued as 10-min and 1-h averages of counts per minute in the real-time monitoring system. Each of the chambers has been calibrated with ^{85}Kr at two concentrations. The calibration results can be used to convert counts per minute into noble gas activity as ^{85}Kr. The 1990 noble gas emissions are based on the median counts-per-minute value for January through December 1990. Then the median counts per minute were converted to an annual noble gas emission as ^{85}Kr.

Data from silica-gel samples were used to calculate tritium emissions from stacks 7025 and 7911. Tritium emissions from the 3039 stack area were based on monthly inventory data of incoming and outgoing shipments and calculated net losses.

Radioactive emissions. The total radioactive airborne emissions for ORNL are presented in Table 2.3. The table lists the total emission for each radionuclide and gross parameter and the percent of the total contributed by each stack. The percent values are based on summed emissions from each stack for the year. Sums for individual radionuclides were tested for statistical significance using laboratory counting uncertainties. If the 95% lower bound calculated from the variance of the sum is greater than zero, then the sum is determined to be significantly different from zero. In the table, percents derived from sums that were determined to be significant are marked with an asterisk.

Trends in historically analyzed emission parameters are presented in Figs. 2.6 through 2.9. The noble gas source term was assumed to be 83% ^{133}Xe and 17% ^{85m}Kr based on data collected at HFIR. An assessment of the potential impacts of the emission source term to the public is presented in Sect. 7.

The tritium source term is lower than that of 1989 (Fig. 2.6). The increase of 7000 Ci in 1989 was within the error associated with estimating losses through inventory calculations at Stack 3039. This method of accounting has been revised to improve the estimates, and emissions at Stack 3039 for 1990 are lower by a factor of two from the 1989 value. In addition, tritium emissions from Stack 7025 were reduced as production work ended at the Tritium Target Fabrication Facility.

Chemical emissions. Total particulate and chemical emissions from any one emission point at ORNL are very low, except for the Steam Plant. Therefore, the air permits issued by the TDC, Air Pollution Control Board, do not require sampling or monitoring at any of the permitted emission points except the Steam Plant. Estimates of major chemical emissions are included in Appendix C.

2.1.3 K-25 Site

Description

As a result of the K-25 Site operations, emission sources may release permitted quantities of various contaminants into the atmosphere. To ensure that these emissions are minimized and that full compliance with CAA requirements is maintained, a comprehensive air pollution control program has been implemented.

This program involves (1) maintenance of a flexible, well-documented environmental policy with regard to air pollution control; (2) continuous review of changes/modifications of air pollution regulations; (3) implementation of projects designed to keep the K-25 Site in full compliance with the CAA; and (4) operational and emissions monitoring to ensure compliance.

Most of these permitted sources are inactive because of the shutdown of the gas centrifuge development program and the gaseous diffusion process. Future permitting activities depend on the introduction of new processes. Table 2.13 in Vol. 2 lists air permits issued by TDC for the K-25 Site.

The locations of airborne radioactive effluent release points at the K-25 Site are shown in Fig. 2.10. All radionuclide emissions were included in all dose modeling. Figure 2.11 describes the general types of air emission sources at the K-25 Site, and Fig. 2.12 depicts the air pollution control program strategy in detail.

Currently, the major operating emission sources are the K-1501 steam plant, the K-1420 decontamination facility, and the K-1435 TSCA Incinerator. For the K-1435 TSCA Incinerator, the estimates of the amount of pollutants emitted are

Table 2.3. 1990 airborne radioactive emissions from ORNL

Radionuclide	Percent contribution by stack[a,b]							Total emission	
	2026	3020	3039	7025	7830	7911	7512	(μCi)	(10^6 Bq)
^{194}Au			100*			0.43*		21	0.78
^{7}Be	<0.0001	<0.0001	98*		2.2*	<0.0001		11	0.41
^{82}Br			100*					5.2	0.19
^{60}Co	0.064	<0.0001	100*		0.0029*	0.0019		190	6.9
^{134}Cs	100*							0.13	0.0047
^{137}Cs	16*	4.7*	79*		0.11*	0.33*		220	8.1
^{154}Eu		100*						0.058	0.0022
^{155}Eu	100*							0.17	0.0064
Gross alpha	52*	9.4*	34*		2.1*	0.88*	1.5*	25	0.92
Grosss beta	1.2*	0.55*	97*		0.60*	0.36*	0.033*	2,900	110
^{3}H			96*	3.9*		0.023*		12,000[c]	440[d]
^{129}I	1.9	11	75		8.8*	2.6	0.56	23	0.85
^{131}I	0.042*	0.0015	5.4*		0.063*	95*	0.0008	20,000	740
^{132}I						100*		910	34
^{133}I	0.0047	<0.0001	0.18*		0.058*	100*	0.0019	22,000	810
^{135}I	0.028	0.0023	<0.0001		0.043*	100*	<0.0001	18,000	660
^{140}La						100*		0.49	0.018
Noble gas			98			1.9		90,000[c]	3,300[d]
^{191}Os			100*				0.0019*	62,000	2300
^{212}Pb	11*	18*	59*		0.53*	11*	0.14*	83,000	3100
^{238}Pu	82*	18*	<0.0001		0.050*	<0.0001		0.16	0.0059
^{239}Pu	76*	22*	2.0*		0.0048*	0.012		0.58	0.021
^{106}Ru			100*					1.4	0.052
^{75}Se			100*					0.75	0.028
^{132}Te						100*		1.7	0.064
^{228}Th	90*	7.6*	1.7*		0.057*	0.83*		0.18	0.0065
^{230}Th	23*	15*	47*		0.70*	14*		0.012	0.00046
^{232}Th	13*	27*	45*		0.90*	15*		0.0088	0.00033
Total Sr	3.3*	3.3*	93*		0.015*	0.34*		110	4.1
Total U[e]	9.6	35	43		1.5	10		0.025	0.00093

[a]Total percentages that exceed 100 are due to rounding.

[b]Values marked with an asterisk (*) represent emissions statistically determined to be significantly different from zero. Note that the variance used in the significance test is based only on the uncertainty associated with laboratory counting and does not include uncertainty due to the sampling process. No significance test was applied to emissions of uranium and noble gas.

[c]Values are curies.

[d]Values are in 10^{12} Bq.

[e]Total uranium emission was 0.034 g.

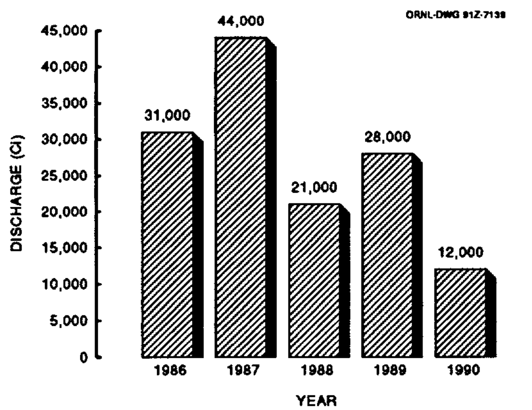

Fig. 2.6. Total discharges of ^{3}H from ORNL to the atmosphere, 1986–1990.

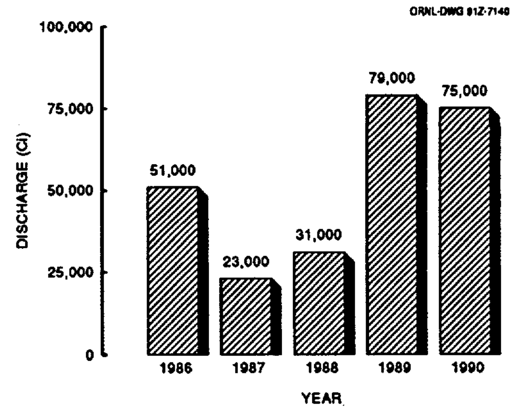

Fig. 2.7. Total discharges of ^{133}Xe from ORNL to the atmosphere, 1986–1990.

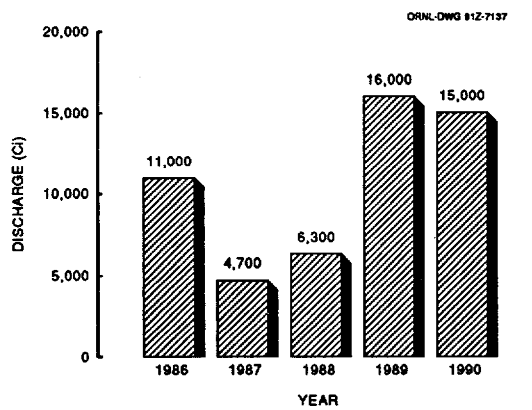

Fig. 2.8. Total discharges of ^{85}Kr from ORNL to the atmosphere, 1986–1990.

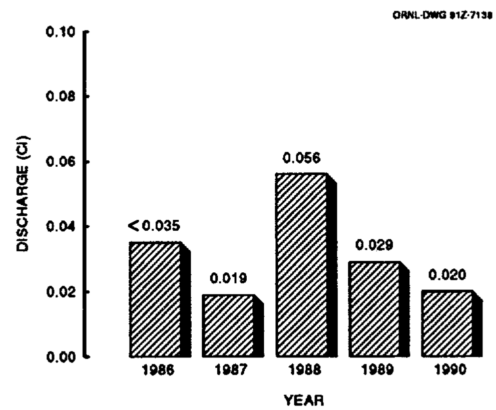

Fig. 2.9. Total discharges of ^{131}I from ORNL to the atmosphere, 1986–1990.

based on actual operating activity. The estimates for radionuclide emissions from the various stacks at K-1420 and the K-1015 laundry are based on both actual operating time in 1990 and stack sampling data obtained in 1989 and 1990.

The K-1501 steam plant is in continuous operation, and this system has a continuous opacity monitor. To reduce opacity excursions, a decision was made to use natural gas as fuel as much as possible. Because sufficient natural gas is not always available during cold winter conditions, some coal can be burned during peak periods of use; less than one ton of coal was burned in 1990, and this was to recertify the boilers.

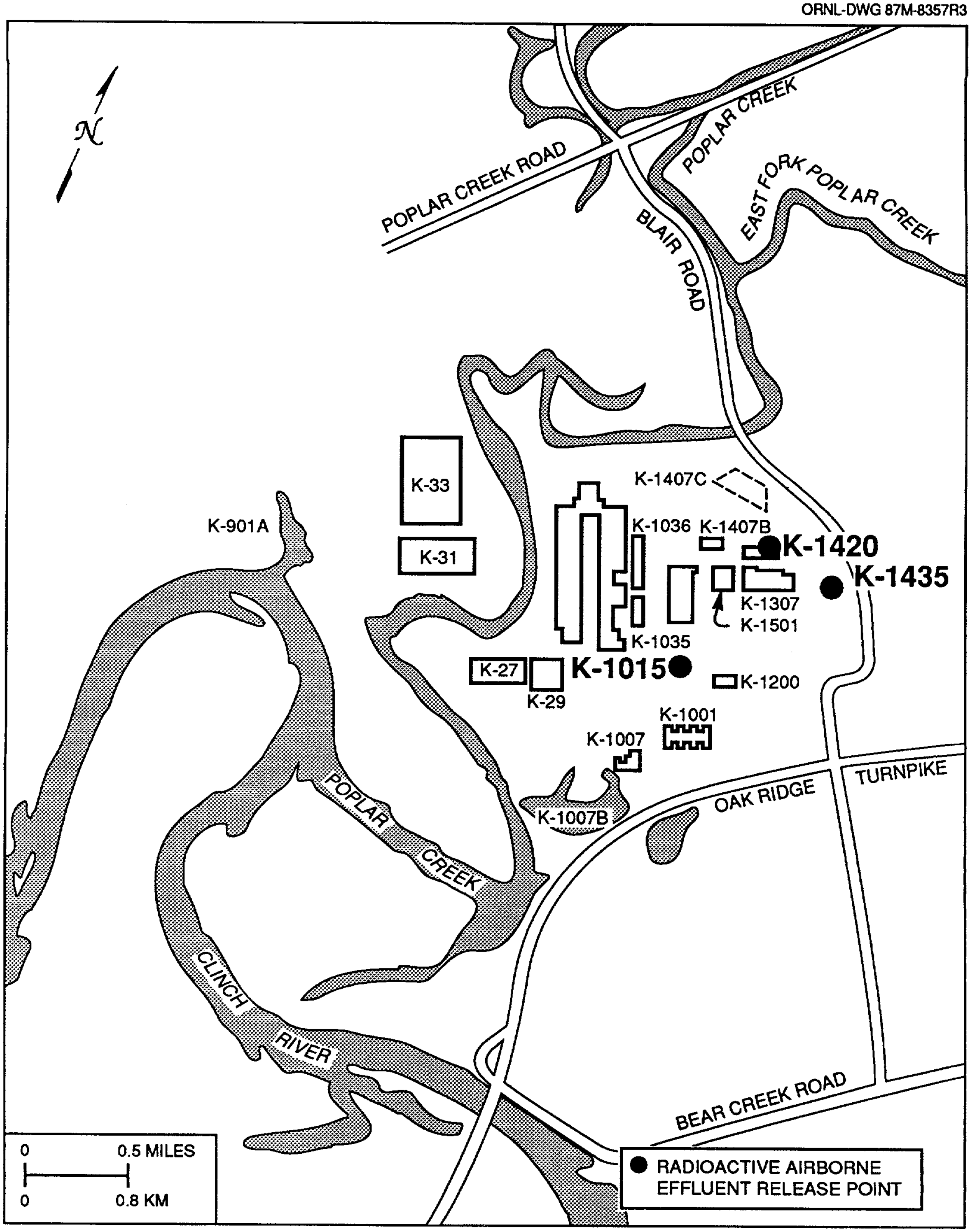

Fig. 2.10. Locations of airborne effluent release points at the K-25 Site.

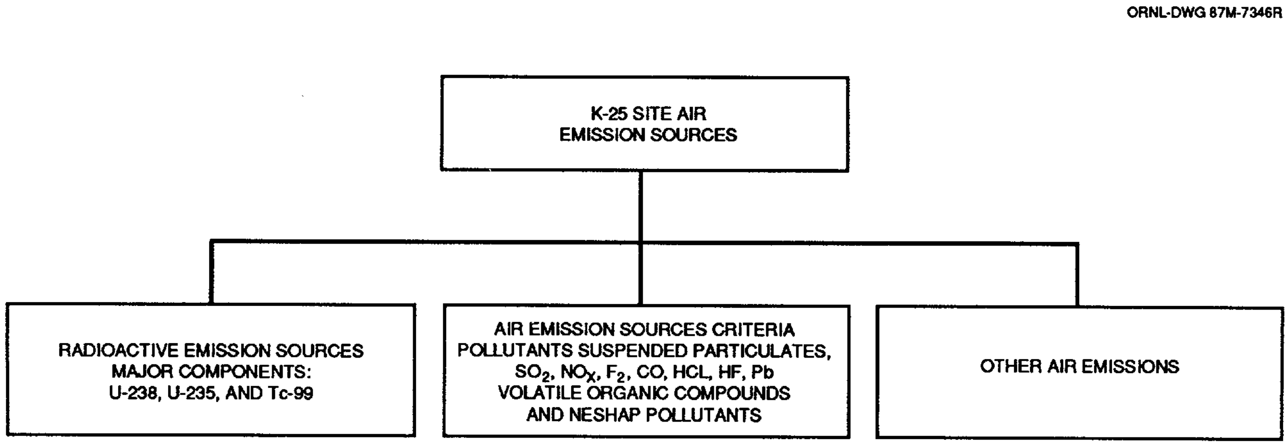

Fig. 2.11. Air emission sources at the K-25 Site.

Estimates of the pollutants emitted from the K-1435 TSCA Incinerator are based on continuous sampling and actual operating time.

The K-1420 decontamination facility used several processes for various types of decontamination in 1990, and for each process used, a triplicate grab stack sample was collected.

The K-1435 TSCA Incinerator, which was built to thermally destroy PCBs and other organic hazardous wastes, has undergone several series of testing to meet the RCRA requirements. TDC plans to modify the RCRA permit to include the conditions that were demonstrated during the trial burn. Current plans are to issue the final permit sometime in 1991.

During the RCRA trial burn, a catastrophic failure of the induced draft fan occurred. A new hasteloy fan was installed, and the incinerator was restarted.

The required TDC air compliance tests for lead, beryllium, and nitrogen oxide emissions were completed, all permitting requirements were fulfilled, and operation began in March 1990. The incinerator began to burn waste in May 1990, and DOE approval for full production is expected in April 1991.

The radioactive isotopes incinerated in the K-1435 TSCA Incinerator during 1990 were uranium, technetium, ^{137}Cs, ^{237}Np, ^{234m}Pa, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{232}Th, and ^{234}Th. The emissions of uranium and technetium are well within the acceptable permit guidelines (15,000 μCi/year for uranium and 394,000 μCi/year for technetium) (see Table 2.4). In addition, carbon monoxide, carbon dioxide, and oxygen are continuously monitored to ensure that destruction efficiency for the incinerator is sufficient to destroy 99.9999% of organics.

There are no permitting requirements to sample or monitor all chemical emissions from the K-25 Site; however, estimates of the major gaseous chemicals emitted to the atmosphere in 1990 (including those that require reporting under SARA Title III, Sect. 3.3) are shown in Appendix C.

Figures 2.13 and 2.14 compare the K-25 Site's discharges of uranium for 1990 with those of previous years. Uranium emissions for 1990 resulted almost entirely from operation and testing of the K-1435 TSCA Incinerator. Samples collected in 1990 detected ^{99}Tc in emissions from K-1420 and K-1435. Figures 2.15 and 2.16 compare the K-25 Site's discharges of ^{99}Tc for 1990 with those of previous years.

2.2 AMBIENT AIR MONITORING

In addition to stack monitoring and sampling conducted at the DOE Oak Ridge installations, an ambient air monitoring program has been developed to directly measure radiological parameters in the ambient air adjacent to the facilities. Ambient air monitoring provides direct measurement of airborne radionuclide concentrations in the environment surrounding the facilities, allows facility personnel to determine the relative level of radioactivity at the monitoring locations during an emergency condition,

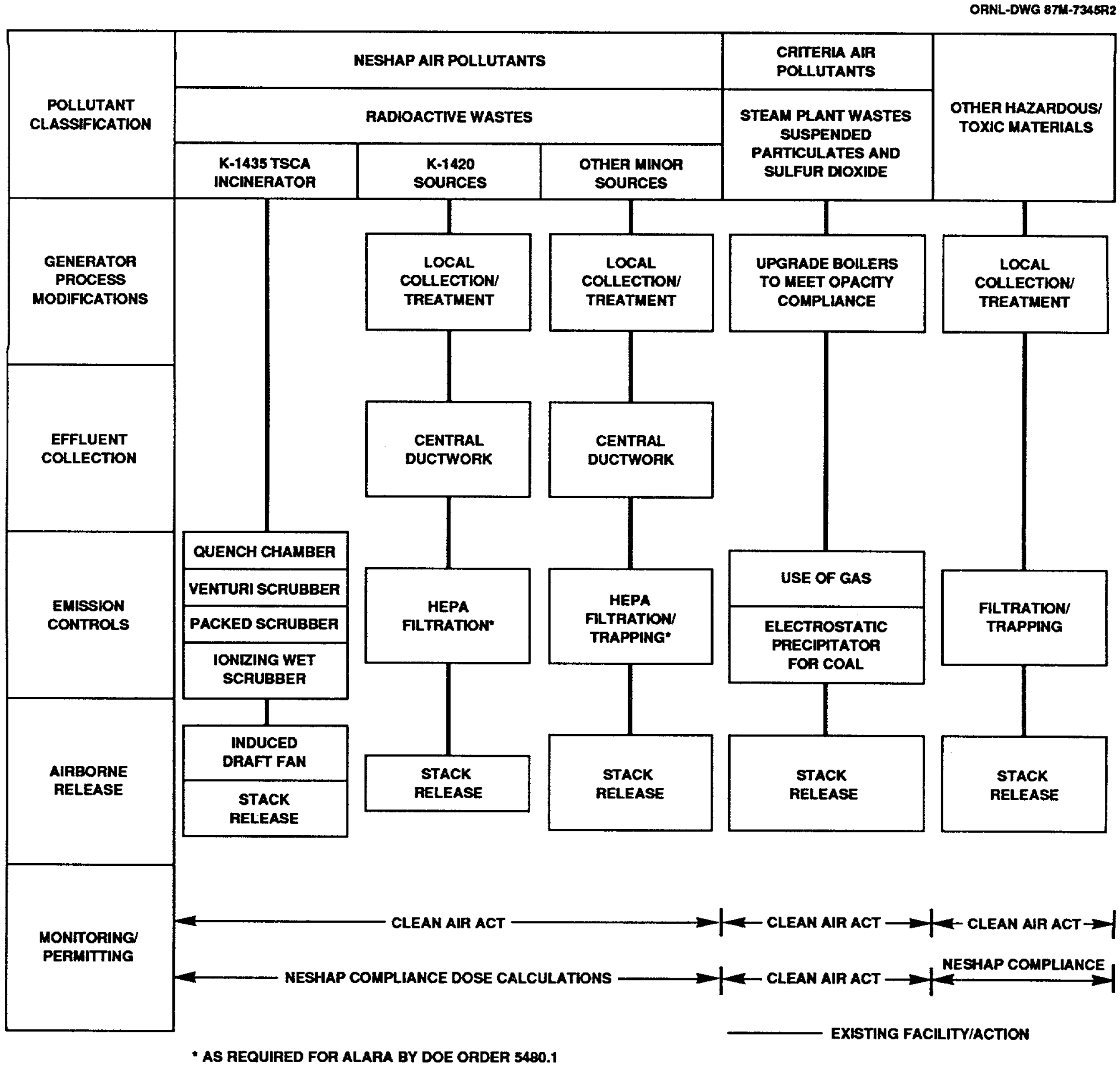

Fig. 2.12. Air pollution control program at the K-25 Site.

and also serves as a check on dose-modeling calculations.

The following sections discuss the ambient air monitoring network for the Energy Systems Oak Ridge installations. This network consists of a number of ambient air monitors located around each facility within the ORR and at remote locations in the surrounding communities. With the exception of perimeter air monitors around the Y-12 Plant and the K-25 Site and TSCA ambient air monitors near the K-25 Site, all ambient air monitors were operated by ORNL during 1990. The following discussions include data summary tables in which 1990 ambient air monitoring results for each station are presented. For a more complete presentation of these data, see Vol. 2, Tables 2.1 through 2.10.

2.2.1 Oak Ridge Y-12 Plant

Description

With the technical assistance of ORNL, the Y-12 Plant has developed a network of ambient air monitors located around the plant perimeter. These stations are to monitor ambient air quality at the plant boundaries to determine the off-site transport of air contaminants and to verify that plant ambient air quality meets air quality standards.

The Y-12 Plant operates 12 ambient air monitoring stations around the perimeter of the plant to routinely measure suspended uranium particulates. Ambient air fluoride sampling is also conducted continuously at 11 of the 12 Y-12 Plant perimeter air monitors. Two additional ambient air monitoring stations are operated to monitor for total suspended particulates (TSP), and two stations were operated through August 1990 to monitor ambient sulfur dioxide concentrations continuously. In 1990, PM-10 samplers were also placed in service at the same locations as the TSP monitors. The locations of the ambient air monitoring stations operated by the Y-12 Plant are shown on Fig. 2.17.

Atmospheric fluoride is collected at 11 sites by absorption on 37-mm-diam (1.5-in.) filters pretreated with potassium carbonate. Ambient uranium sampling is conducted at these same 11 sites and also at an additional site constructed in 1987. Uranium particulates are collected on square 14-cm (5.5-in.) filters and analyzed in the Y-12 Plant laboratory by alpha spectroscopy. Data obtained from ambient uranium and fluoride air sampling are used by Y-12 Plant personnel to assess ambient air quality within the plant and around the plant perimeter. Monitoring of area ambient air quality ensures that plant workers and the general public are adequately protected from potential hazards of stack and other emissions.

The Y-12 Plant monitors TSP in ambient air at the east and west ends of the site. Sampling for TSP consists of drawing air at a known rate through a preweighed filter paper for 24 h every 6 d. From a weight differential resulting from particle accumulation, a particle concentration (expressed in $\mu g/m^3$) can be calculated. These values are compared with the Tennessee primary and secondary ambient air quality standards. Sample results are not submitted to the TDC or EPA but are used as an internal measure of area ambient air quality. If a sample is found to exceed the state standard, Y-12 Plant personnel have the filter scrutinized under a microscope to determine the cause. In all previous cases, the particulate matter did not result from process emissions. Rather, the majority of the filter was covered with road dust, pollen, insects, and other particles arising from the natural environment.

Table 2.4. Total radionuclide emissions from the TSCA Incinerator for 1990

Contaminant	Emission (Ci)
Alpha activity	$(2.61 \pm 0.788) \times 10^{-3}$
Beta activity	$(6.20 \pm 1.79) \times 10^{-3}$
^{137}Cs	$(8.15 \pm 3.06) \times 10^{-4}$
^{237}Np	$(9.18 \pm 2.59) \times 10^{-6}$
^{234m}Pa	$(5.56 \pm 8.45) \times 10^{-3}$
^{238}Pu	$(1.82 \pm 0.796) \times 10^{-7}$
^{239}Pu	$(1.80 \pm 6.05) \times 10^{-7}$
^{99}Tc	$(1.82 \pm 6.84) \times 10^{-3}$
^{228}Th	$(2.03 \pm 2.08) \times 10^{-5}$
^{230}Th	$(1.00 \pm 0.571) \times 10^{-6}$
^{232}Th	$(-2.05 \pm 5.03) \times 10^{-7}$
^{234}Th	$(1.19 \pm 0.793) \times 10^{-3}$
^{234}U	3.63×10^{-4}
^{235}U	1.97×10^{-5}
^{238}U	5.91×10^{-4}

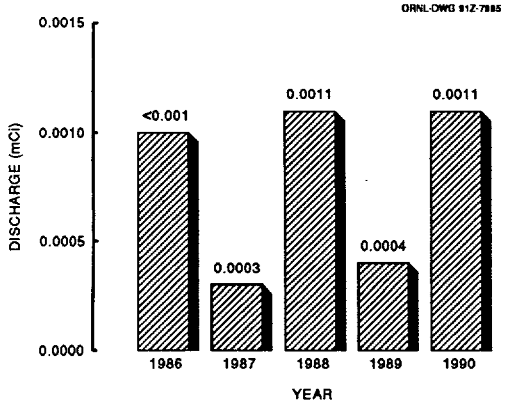

Fig. 2.13. Total curie discharges of uranium from the K-25 Site to the atmosphere, 1986–1990.

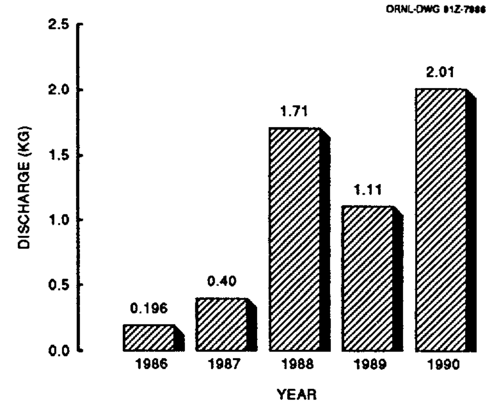

Fig. 2.14. Total kilograms of uranium discharged from the K-25 Site to the atmosphere, 1986–1990.

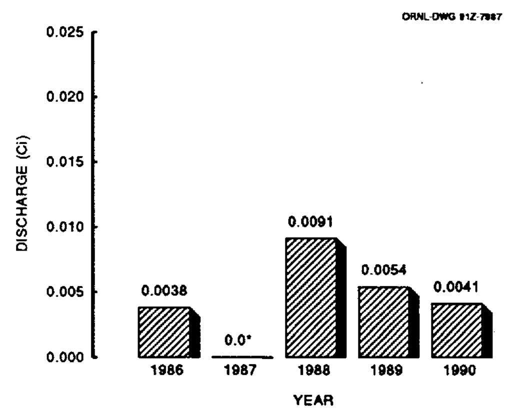

Fig. 2.15. Total curie discharges of ^{99}Tc from the K-25 Site to the atmosphere, 1986–1990. (No ^{99}Tc was detected in 1987.)

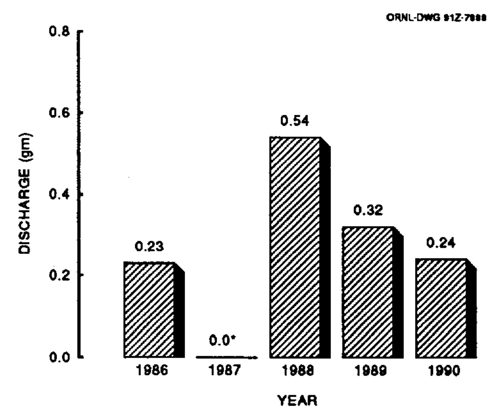

Fig. 2.16. Total grams of technetium discharged from the K-25 Site to the atmosphere, 1986–1990. (No technetium was detected in 1987.)

In 1990, three special PM10 samplers to collect particles smaller than 10 microns were installed adjacent to the existing TSP samplers; one PM10 at the west site and two PM10s at the east site. The PM10s were brought online in the fall of 1990 and are being operated on the same schedule as the TSPs. Data from the two types of particulate samplers will be compared through 1991.

Sulfur dioxide (SO_2) monitoring was conducted continuously through August 1990 at two stations at the Y-12 Plant by pumping ambient air into pulsed ultraviolet fluorescence analyzers that are connected to recording units housed in temperature-controlled shelters. Data from the two SO_2 monitoring stations were reported monthly to the TDC. A quarterly audit of each system was conducted by the TDC for quality assurance purposes. Concentrations of SO_2 were recorded in hourly intervals each month. Hourly averages were combined and compared with 3-h and 24-h air quality standards. In 1990, DOE sent a letter to TDC requesting a waiver from required SO_2 monitoring, based on data collected over the past 5 years and on meeting certain other requirements spelled out in the regulations. The justification was accepted by TDC and written permission to cease SO_2 monitoring was received by DOE and the Y-12 Plant. Monitoring was discontinued at the end of August 1990.

In July 1986, the Oak Ridge Y-12 Plant established a monitoring program to provide a historical database on mercury concentrations in ambient air and to demonstrate protection of the environment and human health from releases of mercury to the atmosphere. Airborne mercury at the Y-12 Plant primarily results from vaporization of mercury in soils, burning of coal at the Y-12 Steam Plant, and fugitive exhaust from Building 9201-4, a former lithium isotope separation facility that is contaminated with mercury.

The Y-12 Plant established four ambient mercury sampling stations in 1986 (stations on the east and west ends of the plant and two stations near Building 9201-4) and added an additional site at New Hope Pond in late August 1987 (Fig. 2.17). With the closure of the pond in December 1988, this site was moved to a new location approximately 700 ft east of the original site. In February 1988, a control site was established at Rain Gage No. 2 (Fig. 2.17) on Chestnut Ridge at the Walker Branch Watershed, bringing the number of mercury air monitoring stations in operation to six. The Rain Gage No. 2 site was subsequently abandoned after collecting data for one calender year to establish the seasonal pattern for the control site.

No established or EPA-approved method of measuring mercury in ambient air existed. The program was begun in 1986, and thus a method was developed by the Environmental Sciences Division staff at ORNL, specifically to meet the needs of the Y-12 Plant. Airborne mercury is collected by pulling ambient air through a Teflon filter, followed by a flow-limiting orifice and an iodated charcoal sampling tube (MSA No. 459003). Mercury collected on the filters and charcoal is analyzed by cold vapor atomic absorption spectrophotometry after digestion in nitric-perchloric acid.

Summary

Ambient air monitoring results for the 12 Y-12 Plant perimeter air monitors are summarized in Tables 2.5 through 2.10. Table 2.5 shows the maximum, minimum, and average gross alpha and gross beta concentrations measured at each of the 12 stations during 1990. Similarly, the ^{234}U, ^{235}U, ^{236}U, and ^{238}U average concentrations are shown in Table 2.6. Table 2.7 shows similar data for ambient fluoride concentration during 1990 as well as a comparison with the state standard for fluorides.

Table 2.8 summarizes the measured SO_2 concentrations at each of the two Y-12 Plant SO_2 monitoring stations through August 1990. Table 2.9 and Figure 2.18 present the mercury monitoring data summarized from the entire sampling period. Table 2.10 shows TSP data for the two Y-12 Plant TSP ambient air monitoring stations during 1990. More detailed data are available in Sect. 2 in Vol. 2, Tables 2.1 through 2.5.

Discussion

Ambient air concentrations of fluorides measured during 1990 at each of the Y-12 Plant perimeter air monitoring fluoride stations were well below TDC standards, averaging less than 1% of the standards.

Ambient uranium isotope concentrations measured at each of the 12 perimeter air monitoring stations around the Y-12 Plant were also very low. Although there is no federal or state standard that applies to ambient uranium or uranium isotope concentrations, measured values are within guidelines set forth under DOE Order 5400.5.

Measured SO_2 concentrations at the two Y-12 Plant air monitoring stations were well below state standards throughout 1990 (see Table 2.3 in Vol. 2).

Table 2.5 in Vol. 2 gives gross alpha and gross beta concentrations in air at the Y-12 Plant for 1990.

TSP samples collected at Y-12 indicated no exceedances of state primary or secondary standards in 1990.

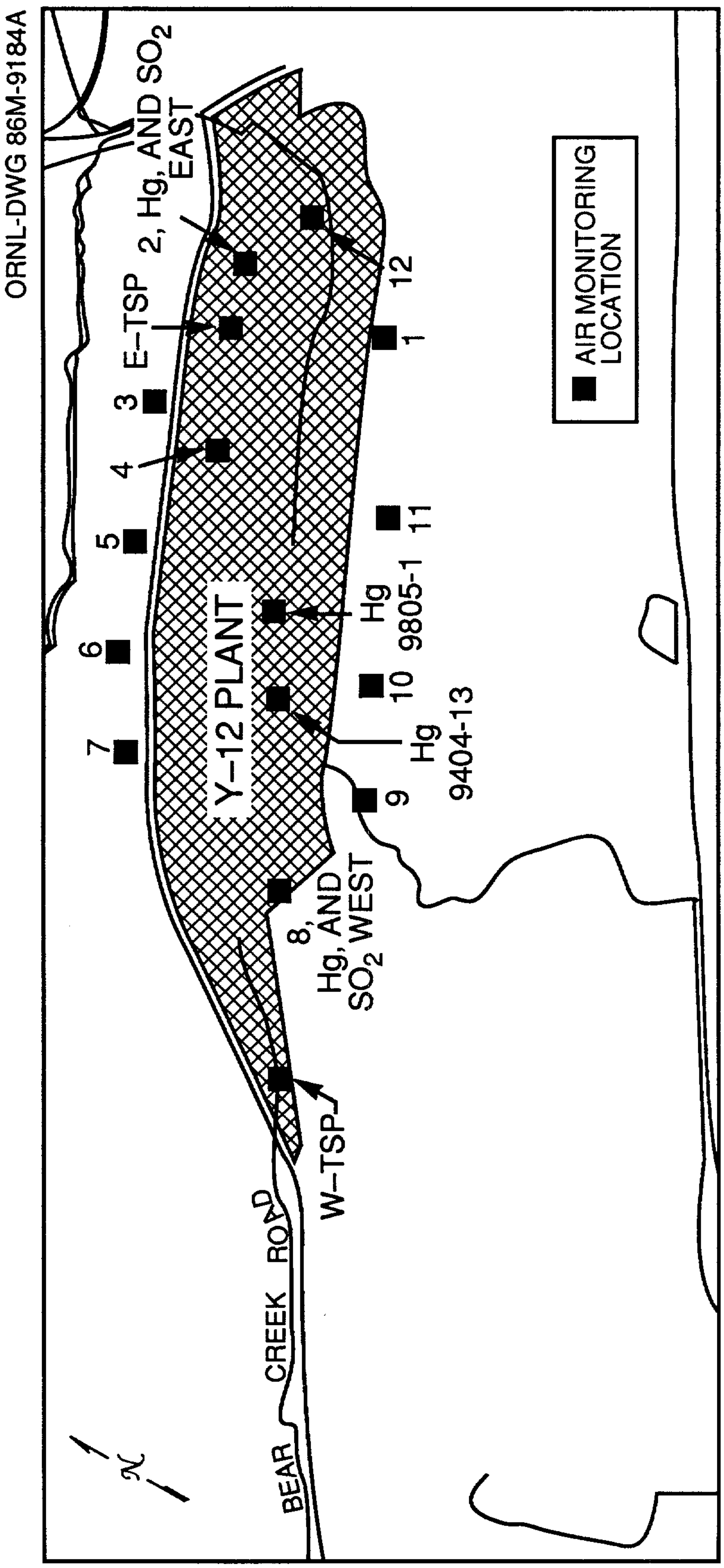

Fig. 2.17. Ambient air monitoring stations operated by the Y-12 Plant.

Data for mercury in ambient air at five monitoring locations at the Oak Ridge Y-12 Plant suggest that the environment and human health are being protected from releases of mercury to the atmosphere. The highest observed concentrations (7-d average) at any monitored site have been 2% of the NESHAP criterion (1.0 $\mu g/m^3$) and <1% of the workplace standard of 50 $\mu g/m^3$. These criteria (1.0 and 50 $\mu g/m^3$) are intended to protect both off-site human populations that are exposed continuously and on-site workers exposed for 8-h work shifts 40 h/week respectively.

The data do show that ambient air mercury concentrations in the Y-12 Plant area are elevated above natural background and may reach greatly elevated concentrations for short periods in localized areas. Disturbances such as excavation of soil in contaminated areas appear to elevate ambient air concentrations of mercury. Ambient air concentrations exhibited a seasonal pattern with the highest values typically occurring in the warmer months and at two sampling sites closest to Building 9201-4, a former lithium isotope separation facility that is contaminated with mercury. The Y-12 Steam Plant may also contribute to locally elevated concentrations of mercury in ambient air because of the presence of mercury in coal. Mercury in coal is not significantly retained (<5%) in particulate control systems such as electrostatic precipitators and baghouses, but it is emitted in vapor form to the atmosphere.

2.2.2 Oak Ridge National Laboratory

Description

The objectives for the ambient program are (1) to sample at stations that were most likely to show impacts of airborne emissions from the operation of ORNL, (2) to maintain surveillance of airborne radionuclides at the ORR perimeter, and (3) to collect reference data from remote locations. Figures 2.19 and 2.20 show the stations that are in the ORNL ambient air program. The specific stations associated with each of these objectives are as follows:

1. The ORNL perimeter monitoring network includes stations 3, 7, 9, 20, 21, and 22 (Fig. 2.19).
2. The DOE ORR perimeter monitoring network includes stations 8 (tritium only), 23, 33, 34, 40, 41, 42, 43, 44, 45, and 46 (Fig. 2.19).
3. The remote monitoring network consists of stations 52 and 58 (Fig. 2.20).

Sampling is conducted at each station to quantify levels of adsorbable gas (e.g., iodine), gross alpha, and gross beta. Stations 3 and 8 are equipped with samplers for measuring tritium. Sampling and analysis frequencies for each station are given in Table 2.11. The real-time monitoring system is the only measure of radioactive noble gases in the area.

Airborne radioactive particulates are sampled biweekly by pumping a continuous flow of air through a 47-mm (1.88-in.) diam paper filter. The airborne adsorbable gases are collected biweekly using a cartridge that is packed with activated charcoal that is in line and downsteam of the particulate filter. The charcoal cartridges are analyzed within 24 h after collection. To minimize artifacts from short-lived radionuclides, the filter paper is analyzed 3 to 4 d after collection. The initial and final dates, time on and off, and flow rates are recorded when a sample medium is mounted or removed. The total volume of air that flowed through the sampler is obtained from a flow totalizer. The concentration of radionuclides in air is calculated by dividing the total activity per sample by the total volume of air sampled.

During 1990, monthly samples for atmospheric tritium were collected from ORNL perimeter station 3 and Reservation perimeter station 8. Atmospheric tritium in the form of water vapor is removed from the air by silica gel. The silica gel is heated in a distillation flask in the laboratory to remove the moisture, and the distillate is counted in a liquid scintillation counter.

Annual composites of particulate air filters from the ORNL perimeter stations (3, 7, 9, 20, 21, and 22), Reservation perimeter stations (23, 33, 42, 43, and 44), remote stations (52 and 58), and some individual stations (34, 40, 41, 45, and 46) are analyzed for specific radionuclides. Annual compositing of the particulate air filters for analysis of long-lived isotopes has been adopted, because the data from previous years showed very low concentrations of these radionuclides. Since the change was made during the year, a combination of quarterly and

Table 2.5. 1990 gross alpha and beta in air at Y-12 Plant perimeter ambient air monitoring stations

Station	Number of analyses[a]	Concentration (10^{-15} μCi/cm^3)[b]		
		Max	Min	Av
		Gross alpha		
1	4	2.49	0.098	1.339
2	4	2.30	0.390	1.312
3	4	4.60	0.641	2.510
4	4	4.18	0.163	1.879
5	4	6.47	0.716	3.331
6	4	5.00	0.293	2.421
7	4	5.04	0.195	2.298
8	4	3.03	0.358	1.686
9	4	2.72	0.293	1.371
10	3	2.84	0.130	1.800
11	4	2.97	0.114	1.483
12	4	3.50	0.358	1.606
		Gross beta		
1	4	16.7	4.285	10.554
2	4	14.2	6.200	10.268
3	4	17.9	5.959	12.337
4	4	18.0	4.527	10.969
5	4	15.2	5.707	10.268
6	4	16.6	6.715	12.389
7	4	16.0	5.979	11.140
8	4	18.4	5.858	11.804
9	4	16.8	6.030	11.285
10	4	18.0	5.858	11.899
11	4	16.8	5.878	10.919
12	4	18.6	6.342	12.323

[a]Gross alpha and gross beta radiation analyses are performed quarterly using a composite of sample filter papers changed out weekly throughout the quarter. For average uranium air concentration data, refer to Table 2.6 and Vol. 2, Sect. 2.
[b]To convert from 10^{-15} μCi/cm^3 to 10^{-11} Bq/cm^3, multiply by 3.7.

longer-interval results is presented. In subsequent years, the program period will be annual.

Data summaries for individual monitoring stations are provided in Tables 2.6–2.10 of Vol. 2.

Summary

Annual data summaries are presented in Table 2.12 for 3 gross parameters and 12 radionuclides. As discussed previously, the data are divided into three groups. The ORNL perimeter air monitors (ORNL PAMs) are designed to evaluate the specific impact of ORNL upon the local air quality. The reservation perimeter air monitors (reservation PAMs) assess the impact of the entire ORR on air quality. Comparing these two sets of data provides insight into the relative impact of ORNL upon the local air quality as compared with other facilities on the Reservation. The remote air monitors (RAMs) provide information on reference concentrations of isotopes and gross parameters for the region. Many of the radionuclides in the data summary are naturally occurring isotopes commonly found in soil, water, and fossil fuels. It is highly unlikely that analyte concentrations at the remote stations are impacted by the operations at the ORR or ORNL. By comparing the ORNL and ORR data with the remote air monitor

Table 2.6. 1990 uranium concentrations in air at the Y-12 Plant

Station	Number of analyses[a]	Concentration (10^{-15} μCi/cm³)[b]			DCG[c] (%)
		Max	Min	Av	
		^{234}U			
1	4	4.220	0.0165	1.2152	4.69
2	4	0.814	0.0234	0.3995	0.90
3	4	3.210	0.3790	1.5496	3.57
4	4	3.160	0.4262	1.4657	3.51
5	4	4.700	0.1021	2.5142	5.22
6	4	2.700	0.3073	1.2216	3.00
7	4	1.110	0.1310	0.5954	1.23
8	4	0.565	0.2343	0.4061	0.63
9	4	1.070	0.2387	0.5950	1.19
10	4	0.400	0.1721	0.2793	0.44
11	4	0.426	0.1115	0.2856	0.47
12	4	0.581	0.1050	0.3210	0.65
		^{235}U			
1	2	0.0202	0.0115	0.0159	0.02
2	4	0.0556	0.0031	0.0249	0.06
3	4	0.1800	0.0115	0.0710	0.18
4	4	0.1150	0.0130	0.0483	0.12
5	4	0.2220	0.0317	0.1284	0.22
6	4	0.1650	0.0170	0.0584	0.17
7	4	0.0723	0.0122	0.0345	0.07
8	4	0.0321	0.0144	0.0199	0.03
9	3	0.0490	0.0287	0.0359	0.05
10	2	0.0236	0.0189	0.0213	0.02
11	4	0.0322	0.0059	0.0195	0.03
12	3	0.0287	0.0071	0.0148	0.03
		^{236}U			
1	2	0.0692	0.0038	0.0365	0.07
2	2	0.0373	0.0077	0.0225	0.04
3	3	0.0433	0.0068	0.0244	0.04
4	3	0.1090	0.0227	0.0461	0.11
5	4	0.0683	0.0106	0.0334	0.07
6	4	0.0397	0.0063	0.0199	0.04
7	3	0.0454	0.0061	0.0243	0.05
8	4	0.0132	0.0071	0.0079	0.01
9	4	0.0504	0.0033	0.0191	0.05
10	2	0.0068	0.0034	0.0051	0.01
11	4	0.0088	0.0031	0.0061	0.01
12	3	0.0154	0.0036	0.0089	0.02

Table 2.6 (continued)

Station	Number of analyses[a]	Concentration (10^{-15} µCi/cm^3)[b] Max	Min	Av	DCG[c] (%)
		^{238}U			
1	4	3.2800	0.0027	0.8515	3.28
2	4	0.1100	0.0156	0.0573	0.11
3	4	0.1030	0.0167	0.0550	0.10
4	4	0.1440	0.0358	0.0835	0.14
5	4	0.1860	0.0229	0.1125	0.19
6	4	0.1900	0.0170	0.0829	0.19
7	4	0.1440	0.0327	0.0907	0.14
8	4	0.1220	0.0683	0.1039	0.12
9	4	0.2450	0.0425	0.1202	0.25
10	4	0.1280	0.0134	0.0754	0.13
11	4	0.2540	0.0188	0.1228	0.25
12	4	0.1160	0.0306	0.0535	0.12

[a]Isotopic uranium determinations are performed quarterly using a composite of samples collected weekly throughout the quarter.

[b]To convert from 10^{-15}µCi/cm^3 to 10^{-11} Bq/cm^3, multiply by 3.7.

[c]Percent DCG = Maximum × 100/derived concentration guide (DCG). The DCG is specified by isotope in DOE Order 5400.5; the most conservative values are used.

Table 2.7. 1990 fluorides in air at the Y-12 Plant

Station	Number of samples	Concentration (µg/m^3) Max	Min	Av	TN std.[a]	Percentage of standard[b]
1	51	0.0245	<0.0070	<0.0116	1.6	0.73
2	51	0.0286	0.0025	0.0121	1.6	0.77
3	51	0.0362	0.0033	0.0135	1.6	0.84
4	51	0.0350	0.0028	0.0127	1.6	0.80
5	51	0.0613	0.0004	0.0130	1.6	0.83
6	51	0.0245	0.0033	0.0108	1.6	0.67
7	51	0.0286	<0.0070	<0.0121	1.6	0.76
8	51	0.0264	<0.0070	<0.0119	1.6	0.74
9	51	0.0385	<0.0070	<0.0117	1.6	0.73
10	51	0.0205	<0.0070	<0.0103	1.6	0.64
11	51	0.0266	<0.0070	<0.0118	1.6	0.74

[a]Tennessee standard 7-d average = 1.6 µg/m^3.

[b]Percentage of standard calculated using average fluoride concentration.

Table 2.8. 1990 sulfur dioxide in air—Y-12 Plant sulfur dioxide monitoring stations

Station	Concentration (ppm SO_2)				
	Annual av	Max 3-h av	Tenn. std. 3-h av	Max 24-h av	Tenn. std. 24-h av
East (004)	0.010	0.123	0.50	0.028	0.14
West (005)	0.006	0.056	0.50	0.016	0.14

Table 2.9. Annual results of the Oak Ridge Y-12 Plant airborne mercury monitoring program, 1986–1990

Site	Year	N	Mercury vapor concentration (µg/m³)		
			Max	Min	Av
Ambient No. 2 (east end of Y-12)	1986	34	0.058	0.003	0.011
	1987	52	0.033	0.001	0.009
	1988	52	0.036	0.003	0.010
	1989	52	0.012	0.003	0.006
	1990	51	<0.018	<0.001	0.006
Ambient No. 8 (west end of Y-12)	1986	27	<0.034	<0.001	0.017
	1987	52	0.067	0.007	0.032
	1988	52	0.407	0.007	0.041
	1989	52	1.187	0.006	0.143
	1990	50	0.025	0.002	0.011
Bldg. 9404-13 (SW of Bldg. 9201-4)	1986	31	0.197	0.033	0.108
	1987	52	0.465	0.044	0.174
	1988	51	0.340	0.028	0.137
	1989	52	0.250	0.024	0.101
	1990	51	0.277	0.001	0.068
Bldg. 9805-1 (SE of Bldg. 9201-4)	1986	15	0.137	0.026	0.070
	1987	52	0.226	0.036	0.109
	1988	52	0.384	0.017	0.097
	1989	51	0.206	0.017	0.072
	1990	51	0.162	0.018	0.071
New Hope Pond[a]	1987	20	0.039	0.006	0.016
	1988	52	0.412	0.004	0.046
	1989	37	0.009	0.002	0.004
Rain Gage No. 2[b] (Chestnut Ridge)	1988	47	0.016	0.002	0.006
	1989	47	0.015	<0.001	0.005

[a]Site discontinued September 19, 1989.
[b]Site discontinued October 31, 1989.

Table 2.10. 1990 total suspended particulates in air—Y-12 Plant TSP monitoring station

Station	Number of samples	Concentration (μg/m^3)					Number of exceedances
		Max	Min	Av	Tenn. Std.	% Std.	
East	57	73.27	5.36	32.25	260	12.4	0
West	57	64.84	6.57	31.75	260	12.2	0

data, the net impact of the ORR and ORNL upon the regional air quality can be assessed.

The data summary consists of the analytical parameters, total samples for the year for each parameter, the range of values, the average, and the standard error. Average concentration values for gross alpha, gross beta, ^{131}I, and tritium are tested for statistical significance using a calculated variance that includes variation from the sampling process and from the laboratory counting process. If the 95% lower bound calculated from the variance of the mean is greater than zero, then the mean is determined to be significantly different from zero. In the tables, averages that were determined to be significantly different from zero are marked with an asterisk.

Only one number is reported for the isotopes at ORNL PAMs and RAMs; this number represents the estimated average concentration for the year. For each isotope, the annual average concentration is divided by the derived concentration guide (DCG) for inhalation of that isotope, multiplied by 100, and presented in the table as the percent of the DCG, unless the percent is less than 0.01. In that case, the percent is reported as <0.01. A discussion of data conventions and the use of negative numbers as well as the definition of DCG is given in the introduction (Sect 1.8).

There appears to have been little or no airborne gross alpha activity at any of the sampling stations during 1990. Differences in the means among networks cannot be detected based on analysis of variance and on Tukey's honestly significant difference test. The averages are slightly higher than the averages for 1989, which can probably be attributed to longer sampling periods.

The gross beta averages for 1990 are comparable to the averages for 1989.

Iodine-131 for ORNL and ORR was less than 0.01% of the DCG. There were no statistically different concentrations of ^{131}I among the ORNL and ORR stations. The tritium concentration for station 3 was 0.033% of the DCG, and for station 8 it was 0.013% of the DCG. Neither isotope is sampled at the remote stations because concentrations have historically been below the analytical detection limits.

Three isotopes exhibited elevated concentrations at the ORR PAMs, as compared with the remote station data. They are ^{234}U, ^{235}U, and ^{238}U. Uranium-234 concentrations were the most elevated, but were only 0.052% of the DCG. The elevated value for ^{234}U is associated with ORR perimeter station 40.

The most likely sources of these increased concentrations are fugitive dusts associated with remedial action activities at the ORR. These stations are located around the Y-12 Plant where construction activities associated with remedial actions are in progress. Additional contributions may be associated with the combustion of coal at the facility steam plants and at the TVA Bull Run Steam Plant.

A comparison of ORNL perimeter air sampling data with the remote air sampling data, using the percent DCG value (Table 2.12), shows that ORNL does not have a significant impact on the local air quality. A similar comparison for the ORR perimeter air sampling data shows that operations on the Reservation are making a very small net contribution to the local airborne radioactivity. Airborne concentrations of radionuclides for the ORNL PAMs and the reservation PAMs ranged from <0.01 to 0.087% of the DCGs. No significant changes in the concentrations of these radionuclides were detected between 1989 data and the 1990 data for the remote stations. Therefore, based on these data, ORR operations have a slight impact on the local air quality but have no significant impact on the regional air quality. The local impact is well below the DCG.

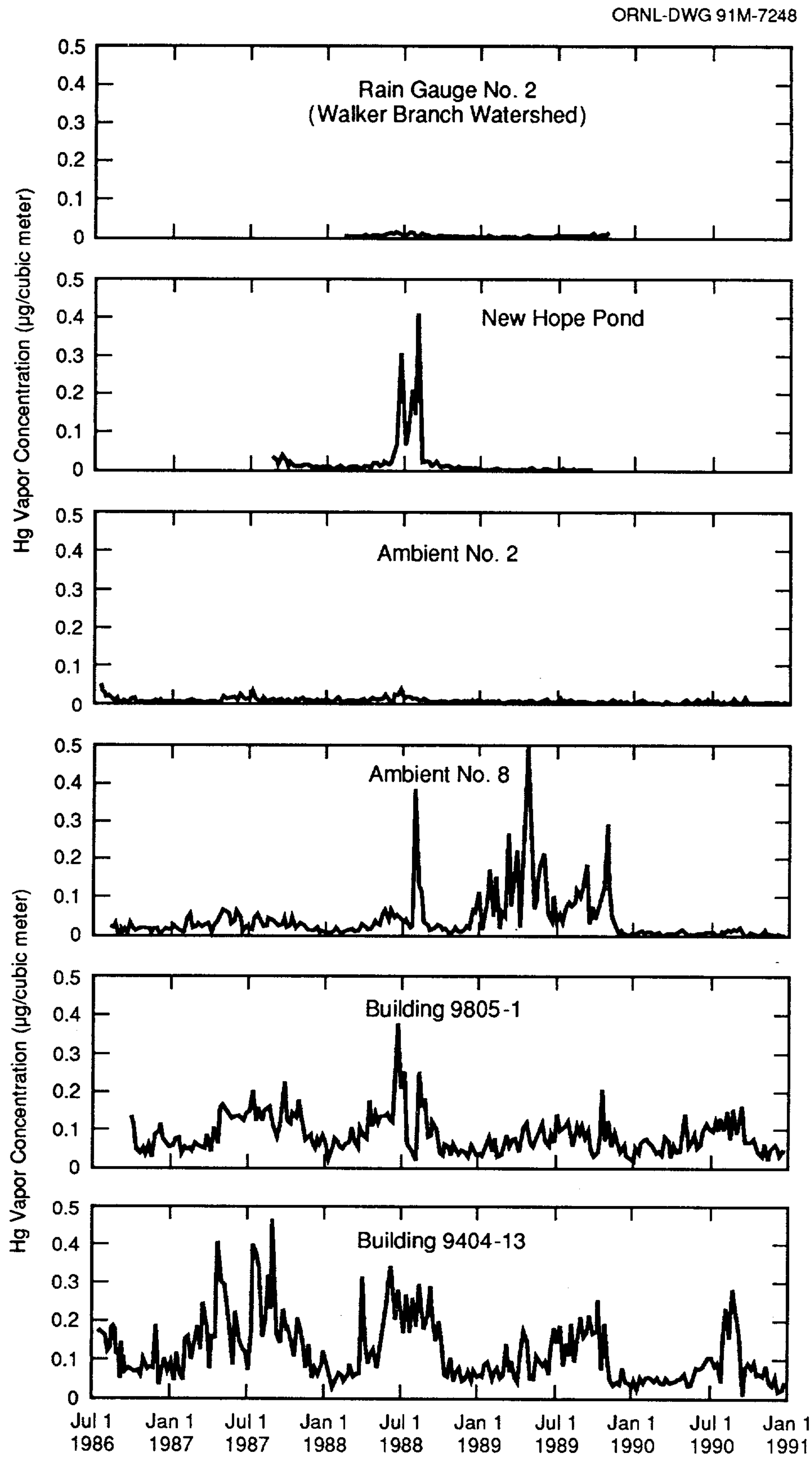

Fig. 2.18. Time trends in mercury vapor concentrations for five monitoring sites at the Oak Ridge Y-12 Plant and Rain Gauge No. 2 at Walker Branch Watershed.

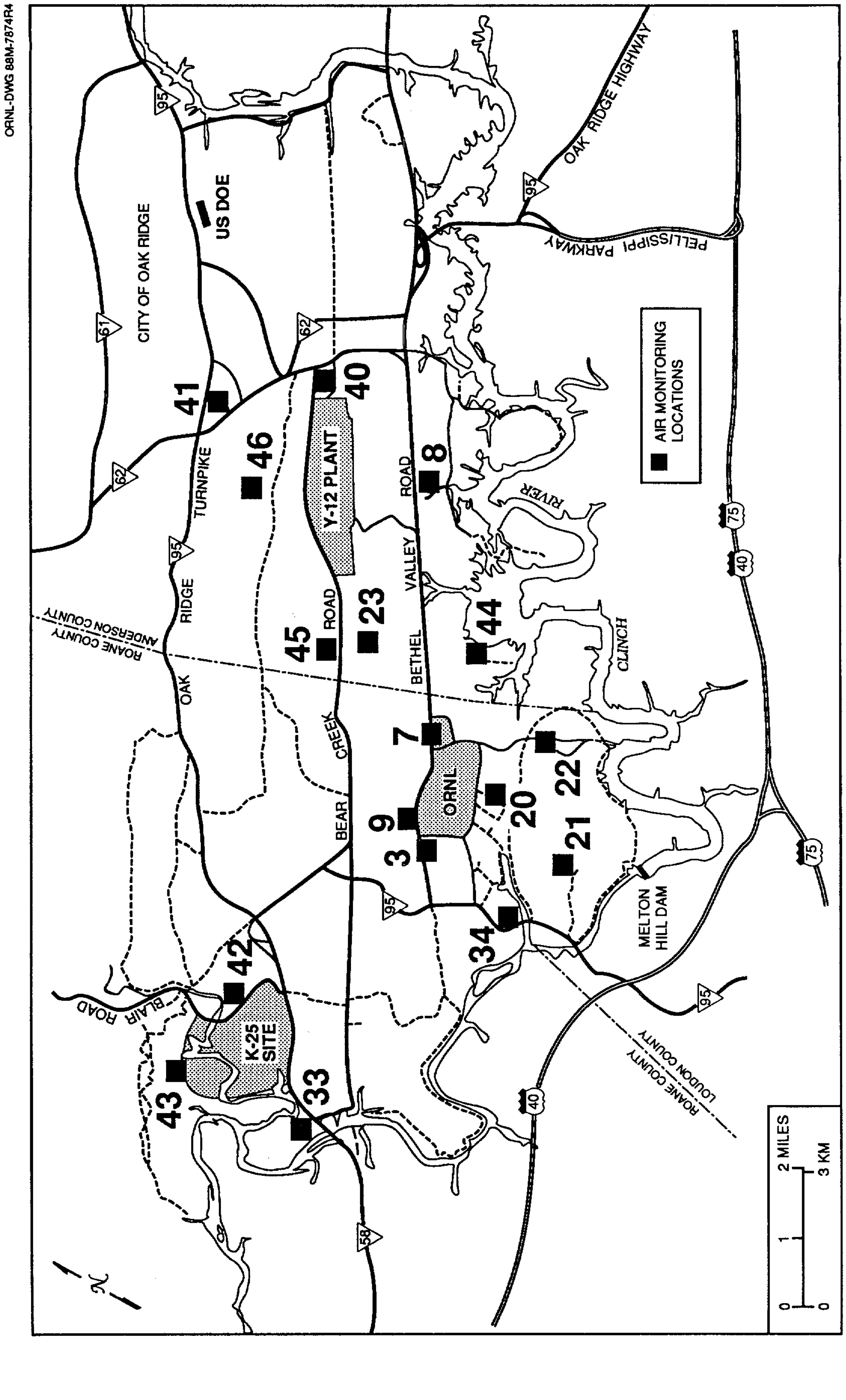

Fig. 2.19. ORR and ORNL perimeter air monitoring locations.

ORNL-DWG 87-7047R4

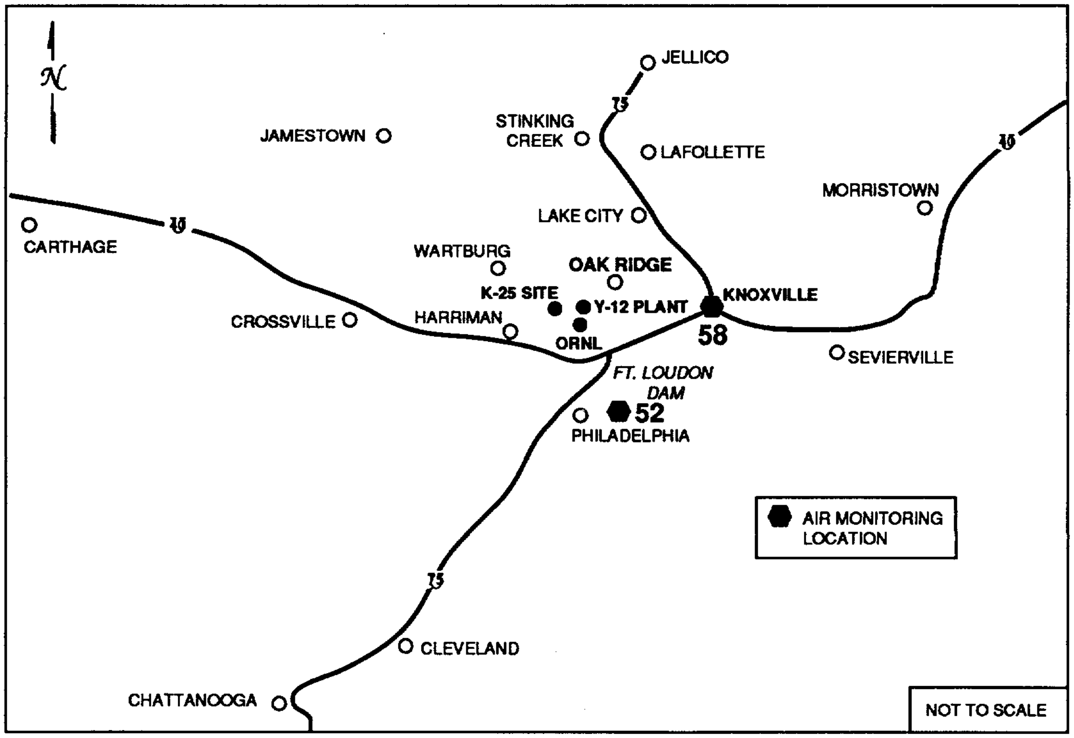

Fig. 2.20. Remote air monitoring locations.

Table 2.11. 1990 summary of collection and analysis frequencies of ORNL air monitoring stations

Station[a]	Parameter	Collection frequency	Type	Analysis frequency
3, 7, 9, 20, 21, 22, 23, 34, 40, 41, 44–46	^{131}I, gross alpha, gross beta	Biweekly	Continuous	Biweekly
33, 42, 43, 52, 58	Gross alpha, gross beta	Biweekly	Continuous	Biweekly
3, 8	Tritium	Monthly	Continuous	Monthly
34, 40, 41, 45, 46, networks	^{60}Co, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{232}Th, total Sr, ^{234}U, ^{235}U, ^{238}U	Biweekly	Continuous	Yearly

[a]See Figs. 2.19 and 2.20.

2.2.3 K-25 Site

Description

In 1986, the K-25 Site's ambient air monitoring program was reevaluated and a new system was designed to ensure improved efficiency and proper placement of monitors and to build monitors consistent with 40 CFR 58, Ambient Air Quality Surveillance. This system became operational January 1, 1987. The K-25 Site now has five ambient air monitoring stations, which are positioned in the predominant wind directions, as shown in Fig. 2.21. These monitors sample ambient air for 24 h every 6th d to be consistent with the TDC TSP sampling schedule. The parameters analyzed for ambient air samples are uranium, nickel, lead, chromium, and TSPs. The results from these samples are evaluated monthly by station for all of these parameters.

In addition to the TSP ambient air monitoring system, a PM10 particulate monitor was added to ambient air monitoring station K4 to comply with the CAA requirement that the state of Tennessee have operational PM10 particulate systems. This monitor has provided 2 years of comparison between the PM10 data and the previous TSP monitoring data prior to obtaining actual operational data.

In 1988, two additional ambient air monitoring stations were designed, sited, and installed at the K-25 Site. These stations were designed to detect PCBs, furans, dioxins, hexachlorobenzene, and uranium that may be released because of possible operational upsets of the K-1435 TSCA Incinerator. The two stations are shown on Fig. 2.21 as TSCA1 and TSCA2.

The TSCA Incinerator ambient air monitors, TSCA1 and TSCA2, are to be operational 24 h/day 7 days/week, as long as the TSCA Incinerator is operational (except when not burning waste). The samples are collected every 48 h and will be analyzed if certain predetermined abnormal operations occurred during that period. During 1990, no samples were analyzed because none of the predetermined abnormal conditions occurred.

Fluoride sampling was not conducted at the K-25 Site in 1990 because of the absence of emission sources. Fluoride sampling may be conducted in the future as needed if new processes emitting fluorine or fluoride become active.

Summary

Table 2.13 summarizes data for each parameter monitored by the K-25 Site ambient air monitoring system. Each monitor, K1–K5 and PM10, was sampled for each parameter 24 h every 6th d throughout the year. The number of samples per location for K1–K5 ranged from 57 to 61. The number of samples taken by the PM10 monitor varied primarily because of startup equipment and added analysis.

As can be seen from the data summary tables, no standards were exceeded. In fact, for TSP, no maximum reading exceeded 77.8% of the secondary standard. For lead, the percentage of standard never exceeded 3.27%.

The PM10 maximum for TSP was roughly equivalent to the TSP maximum for the collocated station, K4.

Work was conducted at ORNL to compare the K-25 Site background data with national ambient levels and to develop internal guidelines for standards for these pollutants. An initial review indicates that the ambient levels of these pollutants detected near the K-25 Site are similar to those found in other rural and industrial areas of the United States.

2.3 METEOROLOGICAL MONITORING

A network of meteorological observation towers provides data on the meteorological conditions and the transport and diffusion qualities of the atmosphere on the Reservation. Data collected at the towers are used in routine dispersion modeling to predict impacts from facility operations and as input to emergency response atmospheric models used in the event of accidental releases from a facility. Data from the towers are also used to support various research and engineering projects.

2.3.1 Description

The meteorological monitoring network, depicted in Fig. 2.22, consists of one 60-m (196.8-ft) tower at the K-25 Site (MT1); one 100-m (328-ft) tower (MT2) and two 30-m (98.4-ft) towers (MT3 and MT4) at ORNL; and one 100-m (328-ft) tower (MT5) and one 60-m (196.8-ft) tower (MT6) at the Y-12 Plant.

Table 2.12 1990 radionuclide concentrations in air

Area[b]	Determination	Number of samples	Concentration (10^{-15} µCi/mL)[a] Max	Min	Av[c]	Standard error	DCG (%)
ORNL PAMs	Gross alpha	117	16	0.11	1.6*	0.17	
	Gross beta	117	71	4.7	22*	1.1	
	^{3}H	13	180,000	2,600	33,000*	14,000	0.033
	^{131}I	118	13	−13	0.30	0.29	<0.01
	^{60}Co	1			0.012		<0.01
	^{137}Cs	1			0.030		<0.01
	^{238}Pu	1			0.00049		<0.01
	^{239}Pu	1			−0.00027		<0.01
	^{228}Th	1			0.0069		0.017
	^{230}Th	1			0.0042		0.010
	^{232}Th	1			0.0033		0.047
	Total Sr	1			−0.0015		<0.01
	^{234}U	1			0.0078		<0.01
	^{235}U	1			0.00027		<0.01
	^{238}U	1			0.0023		<0.01
ORR PAMs	Gross alpha	226	14	−0.11	1.7*	0.11	
	Gross beta	226	55	4.4	23*	0.67	
	^{3}H	11	26,000	260	13,000*	2.8	0.013
	^{131}I	157	8.7	−14	0.19	0.24	<0.01
	^{60}Co	6	0.067	−0.0065	0.019	0.011	<0.01
	^{137}Cs	6	0.028	−0.0052	0.012	0.0060	<0.01
	^{238}Pu	6	0.0023	0.00009	0.00096*	0.00035	<0.01
	^{239}Pu	6	0.00018	−0.0017	−0.00089	0.00030	<0.01
	^{228}Th	6	0.025	0.0076	0.018*	0.0025	0.044
	^{230}Th	6	0.0057	0.0038	0.0049*	0.00032	0.012
	^{232}Th	6	0.0052	0.0030	0.0040*	0.00035	0.057
	Total Sr	6	0.071	−0.014	0.027*	0.013	<0.01
	^{234}U	6	0.11	0.0048	0.046*	0.016	0.052
	^{235}U	6	0.0040	0.00069	0.0024*	0.00057	<0.01
	^{238}U	6	0.012	0.0024	0.0075*	0.0019	<0.01
RAMs	Gross alpha	35	12	−0.14	2.1*	0.45	
	Gross beta	36	74	0.47	26*	2.7	
	^{60}Co	1			0.020		<0.01
	^{137}Cs	1			0.0011		<0.01
	^{238}Pu	1			0.0017		<0.01
	^{239}Pu	1			0.00017		<0.01
	^{228}Th	1			0.018		0.044
	^{230}Th	1			0.0052		0.013
	^{232}Th	1			0.0061		0.087
	Total Sr	1			0.043		<0.01
	^{234}U	1			0.0040		<0.01
	^{235}U	1			0.00091		<0.01
	^{238}U	1			0.0024		<0.01

[a]Multiply µCi/mL by 37×10^{3} to convert to Bq/mL.
[b]See Figs. 2.19 and 2.20.
[c]Averages marked with an asterisk (*) are statistically greater than zero at the 95% level of confidence.

Data are collected at different levels to determine the vertical structure of the atmosphere and the possible effects of vertical variations on releases from facilities. At all towers, data are collected at 10 m (32.8 ft) and at the top of the tower. At the 100-m (328-ft) towers, data are collected at intermediate [30- or 60-m (98.4- or 196.8-ft)] levels also. At each measuring level, temperature, wind speed, and wind direction are measured, while atmospheric stability (a measure of the dispersive capability of the atmosphere) is measured at each tower. Precipitation, humidity, and solar radiation are measured at MT2 at ORNL.

Data from the towers are collected by a dedicated control computer at each site. The towers are polled and data are checked for validity against a predetermined set of parameters, summarized, and filed on disk. Fifteen-minute and hourly values are stored at each site for a running 24-h period. Only hourly data are routinely stored beyond 24 h. The meteorological monitoring data from all towers are checked quarterly, with summaries of data and wind roses, such as the data from MT2 presented in Fig. 2.23. Quarterly calibration of the instruments is conducted for each facility by outside contractors.

Fifteen-minute and hourly data are used directly from the facility computer or the central archival computer for emergency response purposes. The data are received at the emergency response computer dedicated telephone lines and are input to dispersion models. Annual dose estimates are calculated using archived data (i.e., either hourly values or summary tables of atmospheric conditions). In all cases, data quality is checked using predetermined values, and out-of-range parameters are marked as either questionable (requiring interpretation by a competent meteorologist) or invalid (not input to the dispersion models).

2.3.2 Summary

The data presented in Fig. 2.23 are from the 100-m tower located west of ORNL. Wind roses from other tower locations are presented in Figs. 2.1–2.14 of Vol. 2. The information contained in Fig. 2.23 is useful in describing the meteorological conditions of the Reservation. Prevailing winds are generally up-valley from the southwest and west-southwest, or down-valley from the northeast and east-northeast. This pattern is the result of the channeling effect of the ridges flanking the site. Winds in the valleys tend to follow the ridges, with limited cross-ridge flow. Any material released in these valley winds would tend to stay within the valley. These conditions are dominant over the entire Reservation, with the exception of the K-25 Site, which is located in a relatively open area that has more varied flows. However, somewhat weaker valley flows are noted in the K-25 Site area, particularly in locations near the Clinch River.

The winds measured on the Reservation are dominated by low-wind-speed conditions. This characteristic is noted at all tower locations, as is the increase in wind speed with height at which the measurements are made. This activity is typical of tower locations and is important when selecting appropriate data for input to dispersion studies.

The atmosphere over the Reservation is dominated by stable conditions on most nights and in early morning hours. These conditions, coupled with the low wind speeds and channeling effects of the valleys, result in poor dilution of material emitted from the facilities. These features are captured in the data input to the dispersion models and are reflected in the modeling studies conducted for each facility.

Precipitation data from tower MT2 are used in stream flow modeling and in certain research efforts by various divisions. The data indicate the variability of regional precipitation, with high winter rainfall amounts resulting from frontal storms and uneven, but occasionally intense, summer rainfall associated with thunderstorms.

The average data capture efficiency across all 14 tower levels and locations was 91%. The maximum capture efficiency was 98.2%, and the minimum capture efficiency was 85.6%.

2.4 EXTERNAL GAMMA RADIATION

External gamma radiation measurements are made to determine if routine radioactive effluents from ORNL are increasing external radiation levels significantly above normal background levels.

2.4.1 Sample Collection and Analytical Procedures

Gamma radiation measurements are made continuously at ORNL perimeter stations and at ORR perimeter stations (Fig. 2.19). Continuous readings of external gamma radiation are averaged over 10-min

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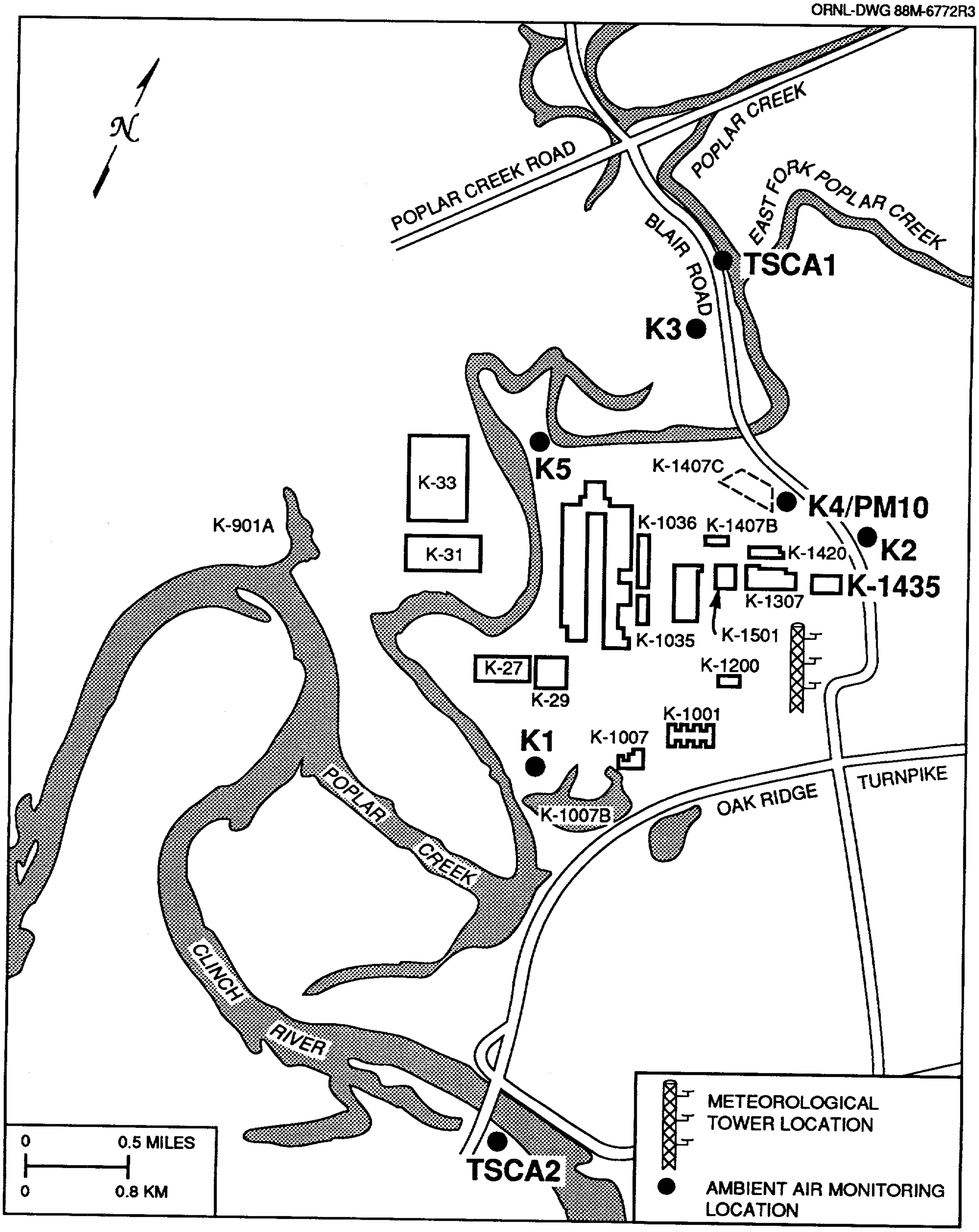

Fig. 2.21. Location of the K-25 Site ambient air monitors and meteorological tower.

Table 2.13. 1990 K-25 Site environmental air sampling

Monitor[a]	Number of samples	Concentration (μg/m³)			Percentage of standard (based on maximum concentration)	
		Max	Min	Av[b]	Primary standard	Secondary standard
			TSP[c]			
1	60	38.0349	<0.0052	<6.7282	14.6	25.3
2	59	36.9431	<0.0050	<6.6175	14.2	24.6
3	61	116.683	<0.0056	<7.6321	44.8	77.8
4	60	49.8707	<0.0038	<8.4626	19.2	33.2
5	60	69.4633	<0.0051	<8.9619	26.7	46.3
PM10	60	53.6607	<0.0056	<8.3107	35.8	35.8
			Lead[d]			
1	60	0.04838	<0.00475	<0.00847	3.2	*e*
2	57	0.01610	<0.00419	<0.00724	1.1	*e*
3	61	0.02207	<0.00447	<0.00761	1.5	*e*
4	60	0.02233	0.00376	<0.00771	1.5	*e*
5	60	0.04331	<0.00446	<0.00815	2.9	*e*
PM10	10	0.01295	<0.00548	<0.00750	0.9	
			Chromium[f]			
1	60	0.01446	<0.00027	<0.00304	*e*	*e*
2	57	0.01207	<0.00025	<0.00271	*e*	*e*
3	61	0.00805	<0.00024	<0.00264	*e*	*e*
4	60	0.00820	<0.00025	<0.00259	*e*	*e*
5	60	0.02721	<0.00024	<0.00311	*e*	*e*
PM10	10	<0.00313	<0.00274	<0.00292	*e*	*e*
			Nickel[g]			
1	60	0.02002	<0.00244	<0.00389	*e*	*e*
2	57	0.00896	<0.00209	<0.00359	*e*	*e*
3	61	0.00819	0.00207	<0.00354	*e*	*e*
4	60	0.01035	<0.00188	<0.00368	*e*	*e*
5	60	0.02388	<0.00024	<0.00370	*e*	*e*
PM10	10	<0.00313	<0.00274	<0.00292	*e*	*e*
			Uranium[h]			
1	60	0.00133	<0.00009	<0.00013	0.9	*e*
2	57	0.00025	<0.00008	<0.00011	0.2	*e*
3	61	0.00014	<0.00009	<0.00010	0.1	*e*
4	60	0.00126	0.00008	<0.00013	0.8	*e*
5	60	0.00072	<0.00009	<0.00012	0.5	*e*
PM10	10	0.00106	<0.00011	<0.00021	0.7	*e*

[a]See Fig. 2.21.

[b]All TSP averages are average geometric mean (AGM).

[c]Primary standards for TSP for the state of Tennessee is 260 μg/m³/24 h and 75 AGM. Secondary standard for TSP for the state of Tennessee is 150 μg/m³/24 h and 60 AGM. PM10 is 150 μg/m³/24 h for primary and secondary standards.

[d]The primary standard for lead is 1.5 μg/m³.

[e]Not applicable.

[f]There are no ambient air standards for chromium.

[g]There are no ambient air standards for nickel.

[h]Standard for the public for natural uranium is 1×10^{-1} pCi/m³, which converts to 0.15 μg/m³. There are no TDC ambient standards for uranium.

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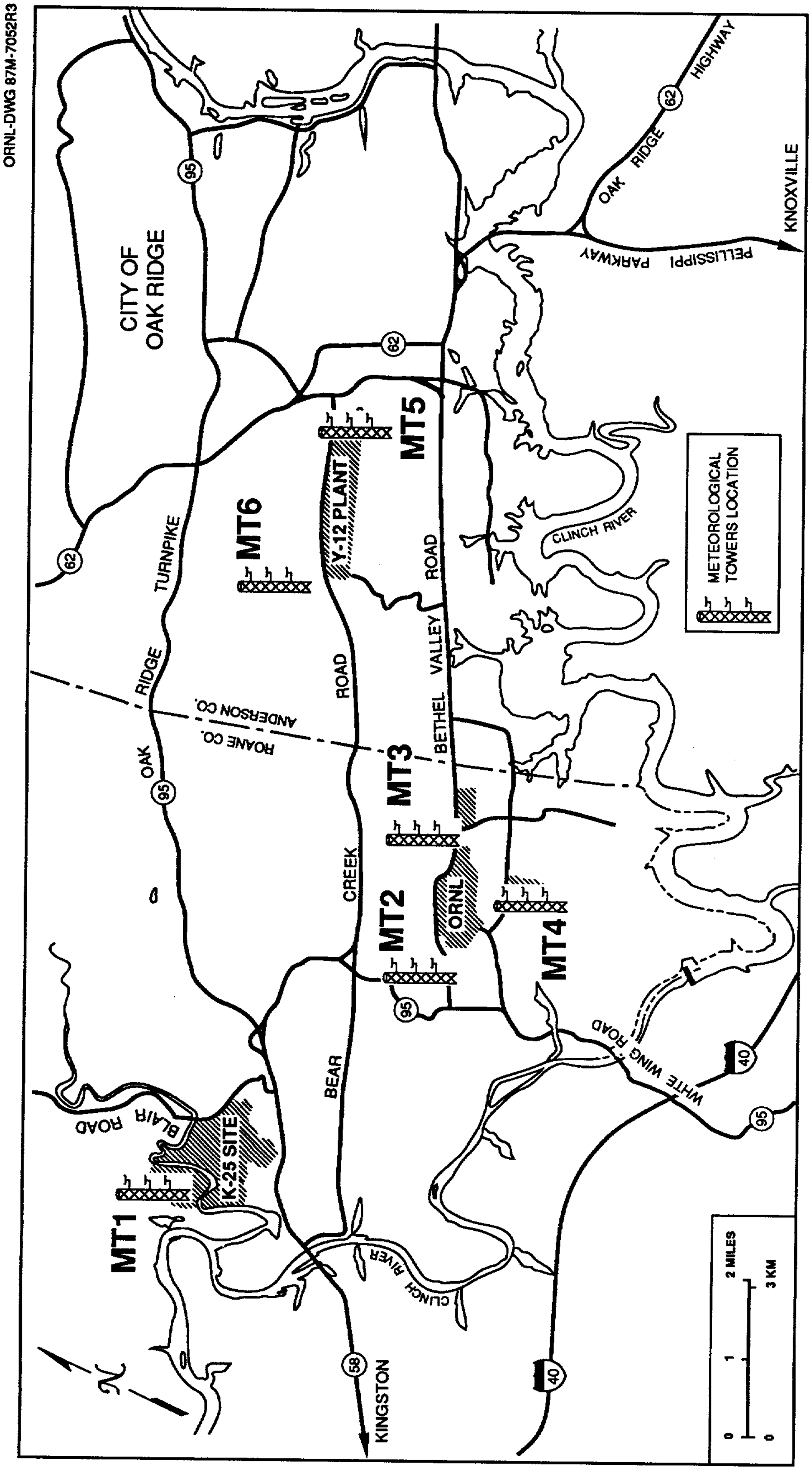

Fig. 2.22. ORR meteorological monitoring network.

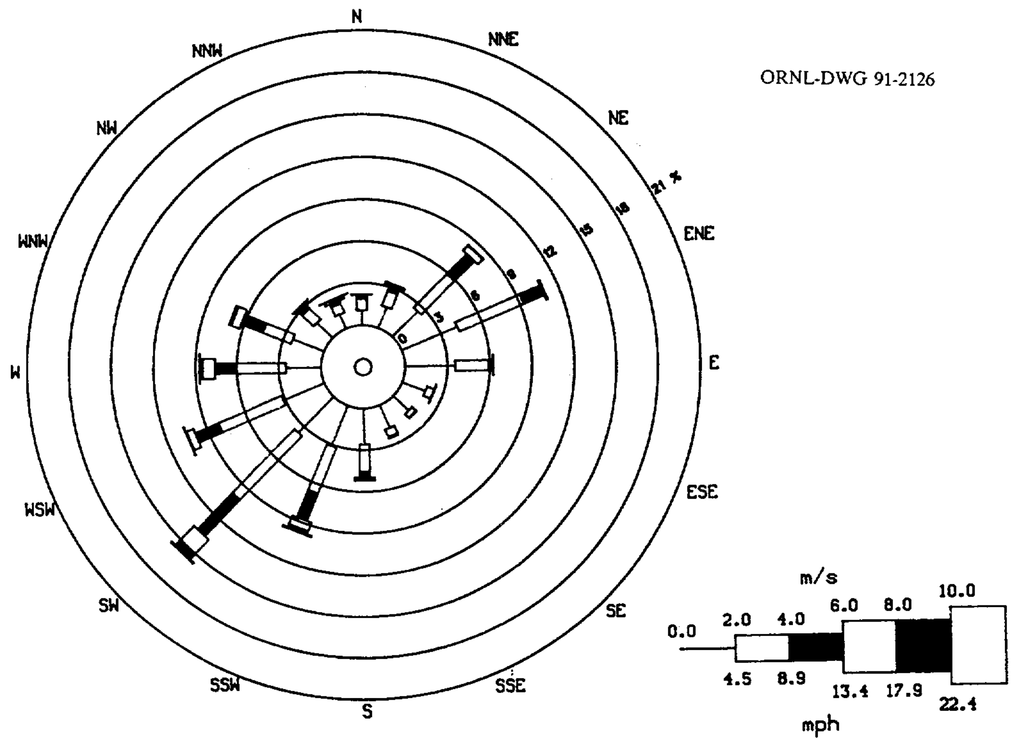

Fig. 2.23. 1990 wind rose for ORNL tower MT2 [100-m (328-ft) level], with 89.8% of possible data.

Table 2.14. 1990 external gamma radiation measurements

Location	Number of samples[a]	Exposure rate (μR/h)			
		Max	Min	Av	Standard error[b]
		ORNL PAM stations[c]			
Network summary	8,600	24	0.53	8.0	0.40
		Reservation PAM stations[c]			
Network summary	57,272	13,000	0.057	7.5	0.23

[a]Real-time readings were collected at all stations at 10-minute intervals. The number of samples indicate the total number of valid hourly averages during the years.

[b]Standard deviation of the mean.

[c]See Fig. 2.19.

intervals for all stations. The real-time monitoring system provides an alert or alarm message if the reading is significantly above a preset background or expected value. These continuous monitoring data are not reported here. The values reported here are summarized from weekly averages of hourly averages that are, in turn, derived from the 10-min readings. A weekly average is considered valid if less than 25% of the hourly values are either missing or invalid because of instrument malfunction.

2.4.2 Results

Table 2.14 presents network summaries of external gamma radiation measurements. The average value for the ORNL perimeter stations was 8.0 μR/h, and the average for the Reservation stations was 7.5 μR/h.

Data for individual ORNL perimeter stations and ORR stations are presented in Table 2.14, Vol. 2. Typical values for cities in the contiguous United States are usually between 5 and 20 μR/h. The median value published by EPA (1987) for cities in the United States during 1987 was 9.3 μR/h, with 75% of the values between 7.5 and 15 μR/h (the distribution is positively skewed). Any contribution to the external gamma signature of ORNL or the other facilities is not distinguishable at these perimeter monitoring locations.

SURFACE WATER

3. SURFACE WATER

The surface waters on the ORR reflect the abundance of limestone and dolomite bedrock as indicated by the presence of dissolved calcium bicarbonate. Hardness is generally moderate; total dissolved solids concentrations usually range between 100 and 250 mg/L.

Water quality in ORR streams is affected primarily by wastewater discharges and by groundwater transport of contaminants from land disposal of waste. Though bedrock characteristics differ somewhat among the watersheds of these streams, the observed differences in water chemistry are most likely attributed to manmade sources rather than to geologic variation. For example, East Fork Poplar Creek (EFPC) shows higher levels of several substances than does any other ORR stream, probably reflecting the influence of effluents from the Y-12 Plant and from the City of Oak Ridge municipal wastewater treatment facility.

Field measurements and sample collections are carried out at various effluent sources and receiving streams on the ORR. Additional sampling is done at the nearest off-site municipal water intake location. Water samples are collected and analyzed at various intervals (weekly, monthly, etc.) for radiological and nonradiological parameters. Surface water data are summarized in this report for water sampling locations both on the ORR and in receiving streams near the ORR. Information not specifically required by an NPDES Permit is presented in the Surface Water section (Sect. 3.1), and all NPDES Permit-related information is summarized in the NPDES Program section (Sect. 3.2).

Concentrations of contaminants in streams and creeks on or around the ORR are compared with Tennessee's in-stream water criteria, which are based on stream classifications and recommendations made by TDC to DOE-ORO. In many cases, allowable effluent concentrations are dictated by discharge permits, which are issued by the TDC. Water quality at the intake for the K-25 Site water treatment plant is compared with Tennessee water quality criteria for domestic water supplies.

In some cases, the maximum concentrations recommended by TDC and EPA are below the detection limit of the most sensitive EPA-approved analytical method.

3.1 SURFACE WATER MONITORING

3.1.1 Radiological summary

Y-12 Plant

Routine surface water monitoring not required by the NPDES permit is performed at Y-12 sites for a variety of reasons. Various radiological parameters are monitored at these sites. These sites are shown in Fig. 3.1.

Kilometer 12.4 on Upper Bear Creek is monitored in response to Section IV, Part 4, of the Memorandum of Understanding agreed to by DOE, EPA, and TDC. This site was agreed upon as a point in the stream that is characteristic of the effects of the seepage of the S-3 Ponds. Because of decreased flow at this site since the closure of the S-3 Ponds, a new site at kilometer 11.97 is also being monitored and will be proposed as a replacement site (Table 3.1). Analytical data are reported to the TDC as an attachment to the Discharge Monitoring Report (DMR) required by NPDES. These sites were monitored once per week for the radiological parameters shown in Table 3.2. Figure 3.2 shows data from 1987 through 1990.

The sampling point for the Lake Reality area is located in the diversion ditch around the New Hope Pond Closure Area. Samples were taken here on a weekly basis for the radiological parameters shown in Table 3.3. In addition, a new sampling point was constructed to monitor East Fork Poplar Creek

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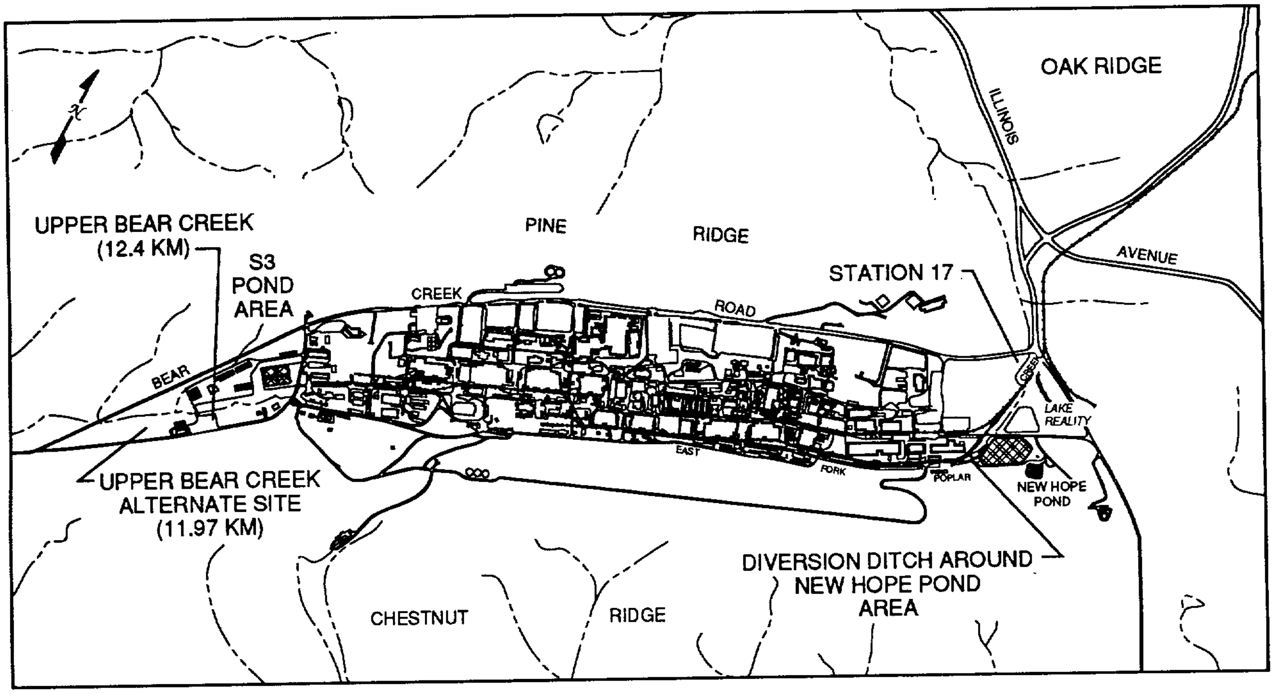

Fig. 3.1. Y-12 Plant non-NPDES routine surface water monitoring sites.

Table 3.1. 1990 annual summary for Upper Bear Creek radiological data (km 11.97)[a]

Parameter	Number of samples	Concentration (pCi/L)				% DCG
		Max	Min	Av	Standard error	
^{241}Am	38	1.10	-0.80	0.21	0.06	0.69
^{237}Np	51	3.70	0.08	0.97	0.11	3.22
^{238}Pu	51	0.75	-0.46	0.02	0.03	0.06
$^{239/240}$Pu	50	0.53	-1.30	0.03	0.03	0.11
^{99}Tc	51	1.52	0.07	0.57	0.05	0.00
Uranium, total (mg/L)	51	0.540	0.015	0.211	0.016	*c*
^{235}U (%)	51	<2.00	0.22	<0.4	0.03	*c*

[a]See Fig. 3.1.
[b]All units pCi/L unless otherwise noted. A negative number is indicative of less than laboratory background value.
[c]Not applicable.

Table 3.2. 1990 Annual summary for Upper Bear Creek radiological data (km 12.4)[a]

Parameter	Number of samples	Concentration[b]				% DCG
		Max	Min	Av	Standard error	
^{241}Am	33	1.40	–0.54	0.15	0.06	0.50
^{237}Np	46	2.70	0.01	0.73	0.08	2.43
^{238}Pu	46	0.39	–1.10	–0.01	0.04	–0.03
$^{239/240}Pu$	45	0.98	–0.21	0.07	0.03	0.22
^{99}Tc	46	0.28	0.02	0.11	0.01	0.0001
Uranium, total (mg/L)	46	0.870	0.027	0.512	0.032	*c*
^{235}U (%)	46	0.64	0.21	0.33	0.01	*c*

[a]See Fig. 3.1.

[b]All units pCi/L unless otherwise noted. Negative number is indicative of less than laboratory background value.

[c]Not applicable.

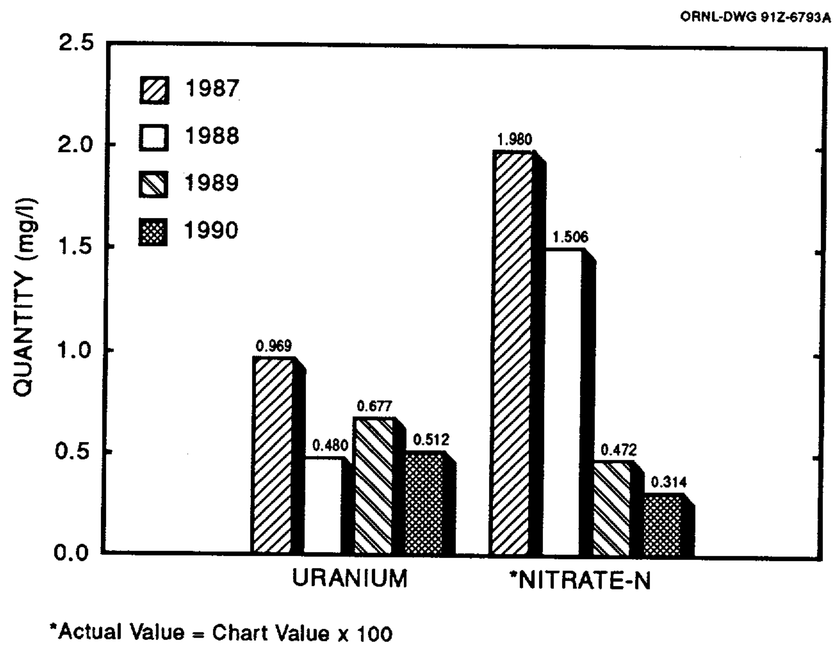

Fig. 3.2. Upper Bear Creek trend chart, 1987–1990.

Table 3.3. 1990 Annual radiological summary Y-12 Plant diversion ditch and Station 17[a]

Parameter	Number of samples	Concentration[b]				% DCG
		Max	Min	Av	Standard error	
		Diversion ditch				
Uranium, total	41	0.066	0.012	0.030	0.002	*c*
^{235}U (%)	41	1.01	0.28	0.52	0.02	*c*
Thorium, total	41	0.009	<0.003	<0.003	0.000	*c*
		Station 17				
Uranium, total	52	0.074	0.012	0.029	0.002	*c*
^{235}U (%)	52	0.99	0.17	0.47	0.15	*c*
Thorium, total	52	0.012	<0.003	<0.004	0.002	*c*

[a]See Fig. 3.1.
[b]Units are in mg/L unless otherwise noted.
[c]Not applicable.

following the final influent, but prior to its leaving the Y-12 Plant boundary. Station 17, located near the junction of Bear Creek and Scarboro roads, was chosen as the ideal site for this monitoring. Weekly samples were obtained here for the radiological parameters listed in Table 3.3.

The Y-12 Plant holds Industrial User's Permit Number 001 with the City of Oak Ridge. This permit allows the Y-12 Plant to discharge wastewater from two main sewerage lines into the Oak Ridge sanitary sewer system in accordance with effluent limitations, monitoring requirements, and other conditions set forth in this permit. The radiological parameters monitored and results obtained in these sewer lines are listed in Tables 3.4 and 3.5. Table 3.6 shows the total uranium and associated curies released from the Y-12 Plant as a liquid effluent during 1988, 1989, and 1990.

Oak Ridge National Laboratory

ORNL collects samples for radiological analyses at off-site locations, at background or reference locations, in streams at the ORNL site, from process discharge point sources, and from various other outfalls. Table 3.7 contains a summary of the current locations, parameters analyzed, and frequencies of sample collection and analysis for all radiological samples (except Category I and II outfall samples). Results from the first three types of locations are summarized in this section. Results from the process points analyses and the categories I and II analyses are deferred to Sect. 3.2, NPDES Monitoring Program, which also contains results for three stream locations covered by the permit. Differences between the current sampling and analysis schedule presented in Table 3.7 and the schedule followed earlier in the year are described as the results are presented.

Treated water samples are collected weekly at the Kingston and the K-25 Site (Gallaher) potable water treatment plants (Fig. 3.3) and are analyzed quarterly. In addition, flow-proportional samples are collected weekly at Melton Hill Dam (MHD) (Fig. 3.3) and analyzed monthly. This sampling location, which is on the Clinch River, is above ORNL's discharge point to the Clinch River (with the exception of the cooling tower, roof, and parking lot runoff at the 7600 area) and serves as a local background or reference station.

DOE Order 5400.5, Chapter II, 3.a. requires comparison of annual average discharge concentrations to DCG values. These concentrations, which result in a dose of 100 mrem/year based upon 2 L/d water consumption, apply at the point of discharge to a receiving stream prior to dilution in the

Table 3.4. 1990 annual radiological summary for West End Sanitary Sewer

Parameter	Number of samples	Concentration				% DCG
		Max	Min	Av	Standard error	
Alpha, pCi/L	12	42.0	6.8	21.9	3.13	*a*
Beta, pCi/L	12	56.0	13.0	28.9	4.28	*a*
^{235}U (%)	12	6.20	1.07	1.97	0.410	*a*
Uranium (total), mg/L	12	0.0120	0.002	0.006	0.0008	*a*
Gamma, pCi/L	12	570	7	153	55.2	*a*

[a]Not applicable.

Table 3.5. 1990 annual radiological summary for East End Sanitary Sewer

Parameter	Number of samples	Concentration				% DCG
		Max	Min	Av	Standard error	
Alpha, pCi/L	12	26	2.9	7.9	1.86	*a*
Beta, pCi/L	12	26	7.3	17.4	1.87	*a*
^{235}U (%)	11	6.3	<0.34	<1.92	0.572	*a*
Uranium (total), mg/L	12	0.013	<0.001	<0.003	0.0010	*a*
Gamma, pCi/L	12	340	15	93	28.3	*a*

[a]Not applicable.

Table 3.6. Y-12 Plant release of uranium to the off-site environment as a liquid effluent

Year	Uranium (Ci)	Uranium (kg)
	Station 17	
1988	0.164	220
1989	0.20	316
1990	0.135	197
	Outfall 304	
1988	0.052	94
1989	0.138	244
1990	0.131	204
	Total off-site release	
1988	0.22	314
1989	0.34	560
1990	0.27	401

Table 3.7. Summary of collection and analysis frequencies of surface and effluent water samples—ORNL, 1990

Station	Collection frequency	Sample type	Parameters	Analysis frequency
7500 Bridge, MB1 (X13), , WOC (X14), MB2	Weekly	Flow proportional	Gamma scan, total Sr[a], ^{3}H	Monthly
First Creek, Fifth Creek, Raccoon Creek	Weekly	Grab	Gamma scan, total Sr[a]	Monthly
Gallaher	Weekly	Time proportional	^{3}H, gamma scan, gross alpha, gross beta, total U, total Sr[a], ^{238}Pu, ^{239}Pu	Quarterly
Kingston	Weekly	Grab	^{3}H, gamma scan, gross alpha, gross beta, total U, total Sr[a], ^{238}Pu, ^{239}Pu	Quarterly
Melton Hill Dam	Weekly	Flow proportional	Gamma scan, gross alpha[b], gross beta[c]	Monthly
NRWTF (X12)	Weekly	Flow proportional	^{3}H, gamma scan, gross alpha, gross beta, total Sr[a]	Monthly
NWT	Weekly	Flow proportional	Gamma scan, total Sr[a]	Monthly
STP (X01)	Weekly	Flow proportional	Gamma scan, gross beta, total Sr[a]	Monthly
WOC Headwaters	Weekly	Flow proportional	Gamma scan, gross alpha[b], gross beta[c]	Monthly
WOD (X15)	Weekly	Flow proportional	Gamma scan, gross alpha, gross beta	Weekly
WOD (X15)	Weekly	Flow proportional	^{3}H, total Sr[a]	Monthly

[a]Total radioactive Sr ($^{89}Sr + ^{90}Sr$).
[b]If gross alpha >27 pCi/L, then analyze for ^{241}Am, ^{244}Cm, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{233}Th, ^{234}U, ^{235}U, and ^{238}U.
[c]If gross beta >810 pCi/L, then analyze for total radioactive strontium.

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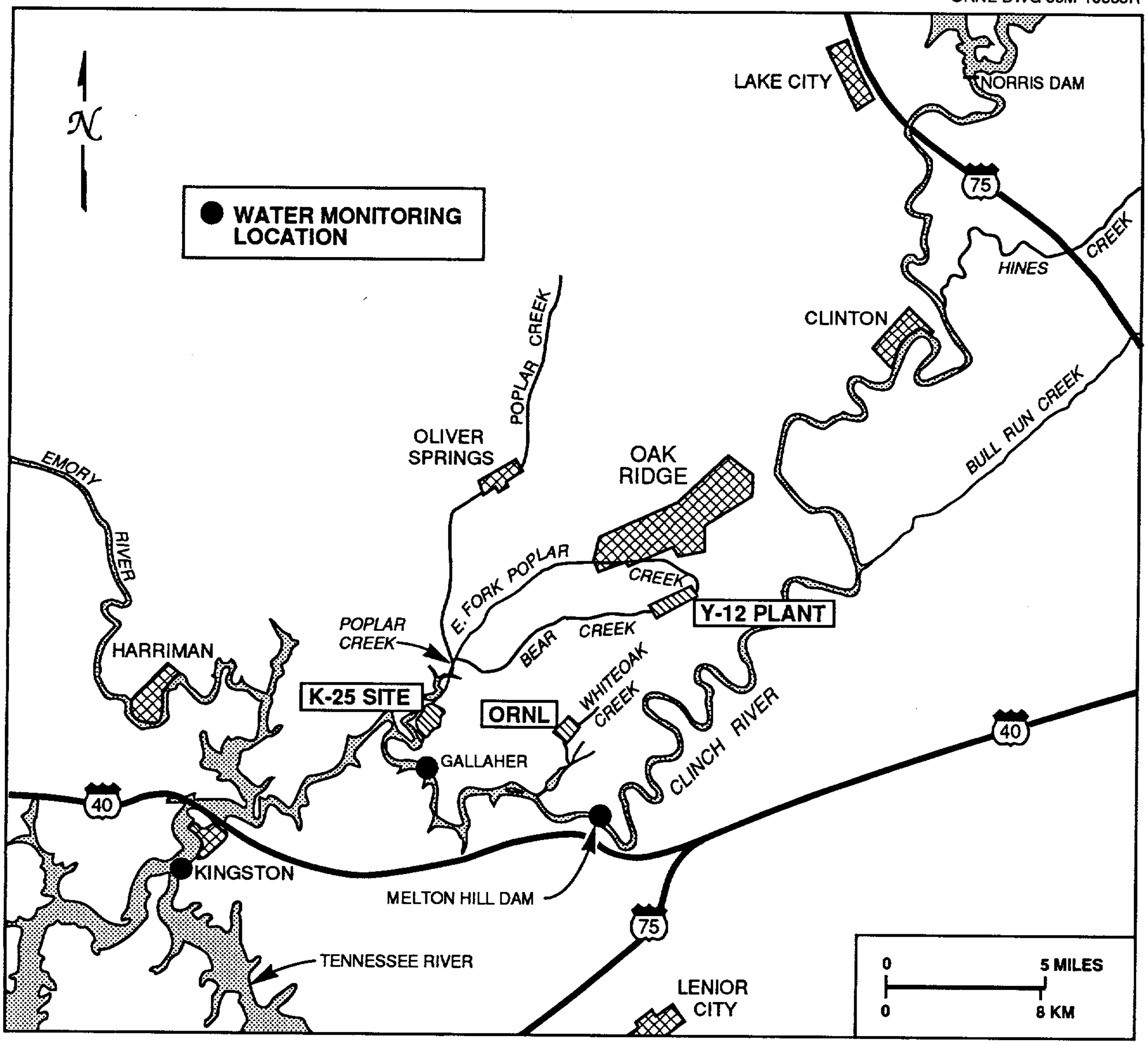

Fig. 3.3. TVA drainage basin near ORR.

stream. The EPA drinking water limits (DWL) apply at the outlet of a public water distribution system and result in a dose of 4 mrem/year based upon 2 L/d water consumption. The EPA standards are more applicable for the Clinch River sampling locations than the DOE DCGs.

The annual radionuclide summaries for the off-site stream-monitoring locations are given in Table 3.8. Average concentration is given as a percentage of the DCG and as a percentage of the EPA drinking water standard. None of the percentages for analytes for which there are DCGs exceeded 0.1%. Average concentrations for analytes with DWLs were all less than 35% of the respective EPA drinking water standard. Few differences were found between the 1989 and 1990 results. Average ^{238}Pu at Gallaher was significantly greater than zero but was less than 0.02% of the DCG.

Surface water samples are collected from six streams near ORNL: White Oak Creek (WOC),

Table 3.8. 1990 ORNL radionuclide concentrations in off-site[a] surface water

Radionuclide	Number of samples	Concentration (pCi/L)[b] Max	Min	Av[c]	Standard error[d]	% DCG[e]	% DWL[f]
				Gallaher			
^{60}Co	4	0.49	0.14	0.29*	0.073	0.0057	*g*
^{137}Cs	4	0.30	−0.027	0.16	0.069	*g*	*g*
Gross alpha	4	0.30	−0.81	−0.074	0.25	*g*	*g*
Gross beta	4	10	2.3	4.8*	1.9	*g*	9.5
^{238}Pu	4	0.0089	0.0030	0.0055*	0.0013	0.014	*g*
^{239}Pu	4	0.013	−0.0086	0.0038	0.0047	*g*	*g*
Total Sr[h]	4	1.2	0.65	0.85*	0.13	0.085	11
Total U[i]	4	0.20	0.065	0.13*	0.027	*g*	*g*
Total U (mg/L)	4	0.00030	0.00010	0.00020*	0.000041	*g*	*g*
^{3}H	4	950	300	690*	140	0.034	3.4
				Kingston			
^{60}Co	4	0.11	−0.14	−0.020	0.050	*g*	*g*
^{137}Cs	4	0.24	0.027	0.12	0.056	*g*	*g*
Gross alpha	4	1.4	0.014	0.50	0.30	*g*	*g*
Gross beta	4	2.3	−2.7	0.79	1.2	*g*	*g*
^{238}Pu	4	0.0035	−0.0078	−0.0026	0.0023	*g*	*g*
^{239}Pu	4	0.027	−0.0021	0.0061	0.0070	*g*	*g*
Total Sr[h]	4	0.35	0.13	0.24*	0.047	0.024	3.0
Total U[i]	4	0.13	0.059	0.080*	0.17	*g*	*g*
Total U (mg/L)	4	0.00020	0.000090	0.00012*	0.000026	*g*	*g*
^{3}H	4	810	54	270	180	*g*	*g*
				Melton Hill Dam			
^{60}Co	12	41	−38	3.6	6.9	*g*	*g*
^{137}Cs	12	46	−38	6.0	7.5	*g*	*g*
Gross alpha	12	25	−1.6	5.2*	2.2	*g*	35
Gross beta	12	24	−24	3.1	4.3	*g*	*g*
^{238}Pu	1	−0.14	−0.14	−0.14	*g*	*g*	*g*
^{239}Pu	1	0.027	0.027	0.027	*g*	*g*	*g*
Total Sr[h]	1	2.2	2.2	2.2	*g*	*g*	*g*
Total U (mg/L)	1	0.00053	0.00053	0.00053*	*g*	*g*	*g*
^{234}U	1	0.41	0.41	0.41*	*g*	0.079	*g*
^{235}U	1	0.081	0.081	0.081	*g*	*g*	*g*
^{238}U	1	0.16	0.16	0.16*	*g*	0.027	*g*

[a]See Fig. 3.3.

[b]Multiply pCi/L by 0.037 to convert to Bq/L.

[c]Mean concentrations significantly greater than zero are identified by an asterisk (*).

[d]Standard error of the mean.

[e]Mean concentration as a percentage of the derived concentration guide (DCG), calculated only when a DCG exists and mean concentration is significantly greater than zero.

[f]Mean concentration as a percentage of the National Primary Drinking Water Level (DWL), calculated only when a DWL exists and mean concentration is significantly greater than zero.

[g]Not applicable.

[h]Total radioactive Sr (^{89}Sr + ^{90}Sr).

[i]Calculated activity, assuming natural abundance.

Melton Branch (MB), First Creek, Fifth Creek, Northwest Tributary (NWT), and Raccoon Creek (Fig. 3.4). Summary statistics for each radionuclide at each surface water sampling location are given in Table 3.1 in Vol. 2. The last column in that table shows the average value for each radionuclide as a percentage of the DCG for water. Data-reporting conventions are discussed in Sect. 1.8.

Average annual concentrations of most radionuclides in surface streams were less than 5% of the DCG. Total radioactive strontium was the predominant exception. Concentrations of this analyte ranged from essentially zero at the reference locations (Melton Hill Dam and White Oak Creek headwaters) to 30% in First Creek and 6.2% at 7500 bridge (about the same as in 1989). Further discussion of these results can be found in Sect. 3.2, NPDES Monitoring Program.

Concentrations and discharges of radioactive contaminants in the on-site creeks and the Clinch River are affected by rainfall, surface runoff, subsurface inflow to streams, and stream flows. Flows in the Clinch River (as measured at Melton Hill Dam) and in WOC [as measured at White Oak Dam (WOD)] are summarized in Table 3.9. Water released at Melton Hill Dam is controlled by TVA. The monthly flow in the Clinch River ranged from 130×10^9 L (34×10^9 gal) for April to 980×10^9 L (260×10^9 gal) for February. The monthly flow in WOC ranged from 0.54×10^9 L (0.14×10^9 gal) for September and November to 2.4×10^9 L (0.63×10^9 gal) for December. The ratio of Clinch River flow to WOC flow is also given in Table 3.9 and was calculated daily and averaged for the month. This ratio is an indication of the dilution factor that is expected for contaminants entering the Clinch River from WOC. The monthly average ratios ranged from 170 (April) to 570 (February and June).

Discharges of radioactivity in WOC and MB and at ORNL's final release point to the Clinch River, WOD, are summarized in Table 3.10. These discharges are calculated by multiplying the concentration for the period (month or week) by the flow volume. At both WOC and MB1, a single flow-proportional sample is analyzed monthly to estimate radionuclide concentrations. At WOD, weekly flow-proportional samples are analyzed. A flow-weighted concentration is calculated for each

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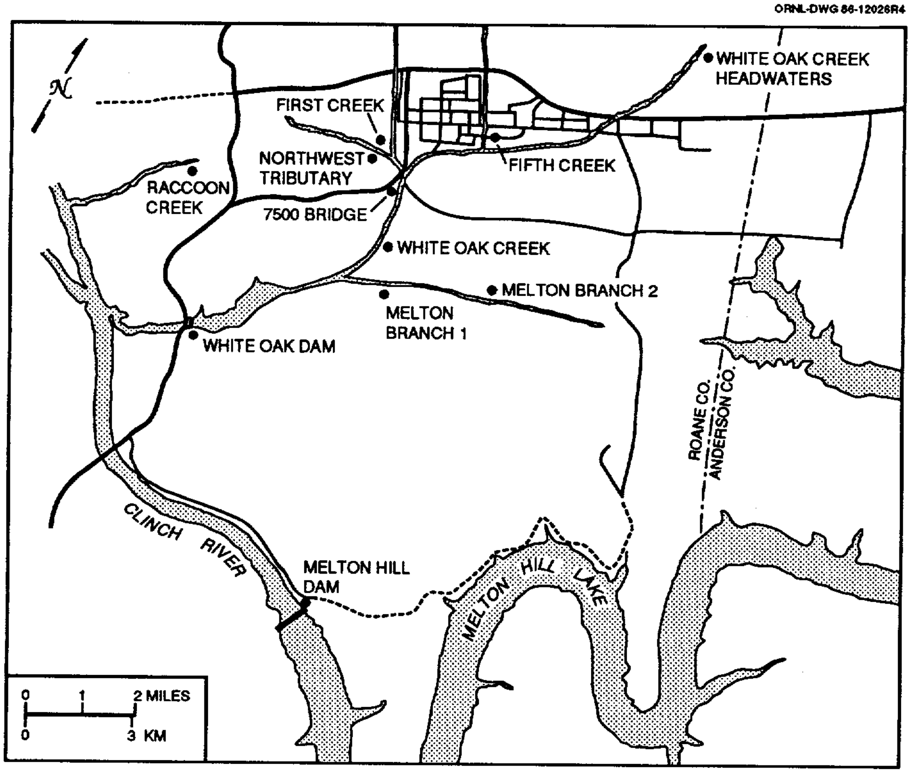

Fig. 3.4. ORNL surface water and reference sampling locations.

Table 3.9. 1990 monthly flows for White Oak Creek at the dam and for Clinch River[a]

Month	Flow (L × 10^9)		Average ratio[c]
	White Oak Dam[b]	Clinch River	
January	2.2	550	340
February	2.2	980	570
March	1.6	360	310
April	0.76	130	170
May	1.9	300	260
June	0.62	340	570
July	0.94	340	460
August	1.1	330	380
September	0.54	280	530
October	0.66	210	320
November	0.54	270	540
December	2.4	420	190

[a]See Fig. 3.4.
[b]White Oak Creek at White Oak Dam.
[c]Flow ratios Clinch River: White Oak Creek at White Oak Dam are calculated daily and averaged for the month.

radionuclide. The discharge is calculated by multiplying this flow-weighted concentration by the total annual flow. The ratio of the flow-weighted concentration to the DCG is also given in Table 3.10. None of the ratios exceeded 42% of the DCG. The highest average concentrations were for ^3H and total Sr at MB1, which were lower than the averages observed during 1989.

K-25 Site

Surface water samples are collected as part of the CWA requirements and DOE orders. Both NPDES and perimeter ambient water sampling locations under K-25 Site responsibility are shown in Fig. 3.5. Table 3.11 lists sampling locations, sample type, the agency requiring the sample, and the NPDES identification number where applicable.

Perimeter monitoring includes both water quality parameters and radionuclides. The purpose is to document the K-25 Site's impact on the surrounding streams and to differentiate the impact from that of other sites.

During 1990, grab samples were collected once a quarter at the following locations: the Clinch River, West Fork Poplar Creek, and Mitchell Branch source. At K-1513, K-716, K-1710, and K-1770, 24-h composite samples were collected once each month. All samples were analyzed for radiological and nonradiological parameters.

Table 3.2 in Vol. 2 gives radiological data from the ambient surface water surrounding the K-25 Site. Figure 3.5 gives the sampling locations.

Differences seen in the 1990 data as compared to the 1989 were slight increases in plutonium in Poplar Creek. Neptunium also increased upstream of the plant in the Clinch River. Gross alpha, beta, and gamma are not significant within Mitchell Branch.

3.1.2 Nonradiological summary

Y-12 Plant

Nonradiological parameters were also monitored at the non-NPDES Y-12 sites listed in Sect. 3.1.1 and illustrated in Fig. 3.1. These sites are also described more fully in that section.

A nonradiological parameter summary for kilometer 12.4 and kilometer 11.97 on Upper Bear Creek can be found in Tables 3.12 and 3.13.

Station 17, located below Lake Reality, is now the plant's end monitoring point for nonradiological parameters. Grab samples are obtained here twice per day for mercury, and composite samples are obtained

Table 3.10. 1990 ORNL liquid radioactive discharges and concentrations

Radionuclide	Discharge[a] (Ci)	Concentration guide (DCG)[b] (pCi/L)	Concentration[c] (pCi/L)	Percentage of DCG[d]
		Melton Branch 1		
^{60}Co	0.085	5,100	23*	0.44
^{137}Cs	0.014	3,000	3.8*	0.13
Total Sr[e]	1.6	1,000	420*	42
^{3}H	2,500	2,000,000	680,000*	34
		White Oak Creek		
^{60}Co	*f*	5,100	−2.1	*f*
^{137}Cs	2.0	3,000	170*	5.6
Total Sr[e]	1.8	1,000	150*	15
^{3}H	1,000	2,000,000	84,000*	4.2
		White Oak Dam		
^{60}Co	0.12	5,100	7.8*	0.15
^{137}Cs	1.1	3,000	71*	2.4
Gross alpha	0.079	*f*	5.1*	*f*
Gross beta	6.8	*f*	440*	*f*
^{191}Os	0.014	70,000	89*	0.13
^{238}Pu	*f*	41	−0.081	*f*
^{239}Pu	*f*	30	−0.081	*f*
Total Sr[e]	3.1	1,000	200*	20
Total U (g or mg/L)	460[g]	*f*	0.0036*[g]	*f*
^{3}H	3,100	2,000,000	200,000*	10
^{234}U	0.00066	510	5.1*	1.0
^{235}U	0.00022	590	1.7*	0.29
^{238}U	0.00012	590	0.92*	0.15

[a]Discharges are calculated from flow and concentration and are listed when concentrations are significantly greater than zero. Multiply Ci by 3.7×10^{10} to convert to Bq.

[b]Derived concentration guide for ingestion of water (from DOE Order 5400.5).

[c]Concentrations significantly greater than zero are identified by an asterisk (*). Multiply pCi/L by 0.037 to convert to Bq/L.

[d]Mean concentration as a percentage of the DCG, calculated when a DCG exists and the mean concentration is significantly greater than zero.

[e]Total radioactive Sr ($^{89}Sr + ^{90}Sr$).

[f]Not applicable.

[g]Discharge for Total U in g; concentration for Total U in mg/L.

Table 3.11. K-25 Site water monitoring locations

Location	Agency	Type	NPDES ID if applicable
Clinch River (Brashaer Island)	DOE	Perimeter	
West Fork Poplar Creek	DOE	Perimeter	
K-710A (inactive)	TDC	NPDES	008
K-716	DOE	Perimeter	
K-901-A	TDC	NPDES	007
K-1007-B	TDC	NPDES	006
K-1203	TDC	NPDES	005
K-1407-E and K-1407-F	TDC	NPDES	010
K-1407-J	TDC	NPDES	011
K-1513	DOE	Perimeter	
K-1515-C	TDC	NPDES	009
K-1700	TDC	NPDES	001
K-1710	DOE	Perimeter	
K-1770	DOE	Perimeter	

one day per week on a rotating day of the week basis. These results are summarized in Table 3.14.

Nonradiological samples are obtained from the two sanitary sewer lines as required by the Industrial User's permit. These results are summarized in Tables 3.15 and 3.16.

Nonradiological analyses

At the Y-12 Plant, surface water is monitored routinely at locations that are not required by the plant NPDES permit (TN0002968) (Fig. 3.1). At each of these locations, samples are collected for both radiological and nonradiological parameters.

The first location is at kilometer 12.4 (mile 7.7) on upper Bear Creek where the creek first approaches Bear Creek Road. As required by the 1983 complaint and order issued by TDC to the Y-12 Plant, grab samples are collected weekly at this location. Due to decreased flow conditions, a more representative monitoring point is also sampled (kilometer 11.97). Analytical data are reported quarterly to TDC as an attachment to the DMR. (A summary of 1990 data is presented in Table 3.1.)

Monitoring is also conducted at Station 17 near the junction of Scarboro Road and Bear Creek Road. The samples at this point indicate the quality of the water in EFPC just before it leaves the Y-12 Plant boundary. Most of the samples collected at this location are flow-proportional, 24-h composites. Both radiological and nonradiological parameters are analyzed at this location, and data collected are used for a variety of purposes. See Table 3.4 for a summary of 1990 data.

The Y-12 Plant sanitary sewage system discharges to the City of Oak Ridge sanitary sewer through two sewer lines. The wastes are treated at the City of Oak Ridge West End Treatment Facility. These discharges are monitored as required in the industrial users' permit No. 001 issued to the Y-12 Plant. These data are summarized in Tables 3.5 and 3.6.

Oak Ridge National Laboratory

Monthly surface water samples were collected at two sampling locations for the purpose of determining background concentration levels before the influence of ORNL. The two locations are MHD above ORNL's discharge point into the Clinch River (with the exception of the cooling tower, roof, and parking lot runoff at the 7600 area) and White Oak Creek Headwaters (WOCH) above the point where ORNL discharges to WOC (see Fig. 3.4). The samples were analyzed and inorganic elements and compounds. The results of these analyses help to assess surface water quality independent of impacts from ORNL.

Table 3.17 contains a summary of the analytical results. The percent DWL column shows the average annual concentration as a percentage of the National Primary or Secondary Drinking Water Regulation

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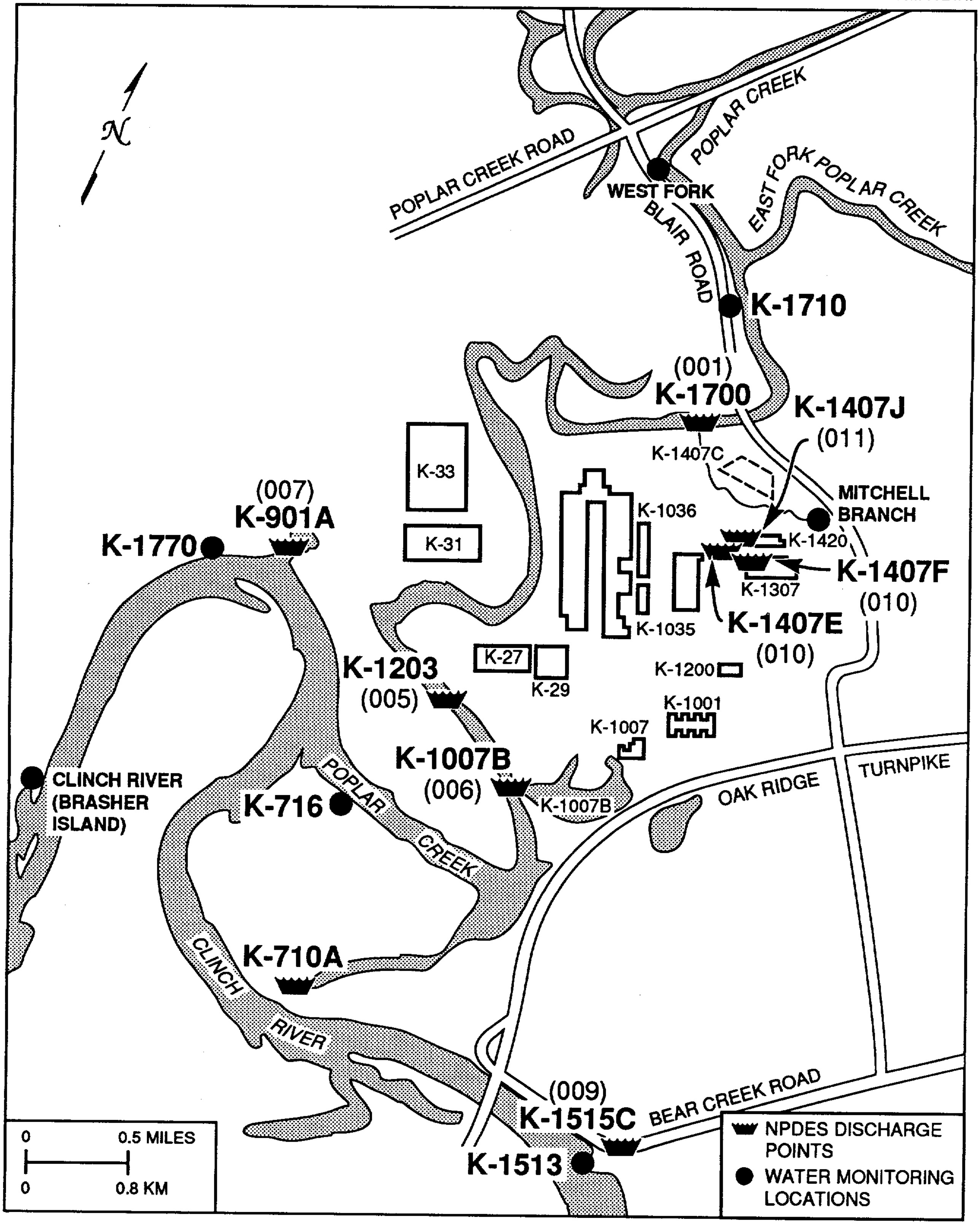

Fig. 3.5. K-25 Site NPDES and perimeter monitoring locations.

Table 3.12. 1990 Y-12 annual summary for Upper Bear Creek nonradiological data (km 12.4)[a]

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error
Arsenic	46	<0.040	<0.001	<0.007	0.001
Cadmium	43	0.021	<0.0001	<0.0013	0.0005
Chromium	46	0.007	<0.001	<0.002	0.000
Cyanide	46	0.011	<0.002	<0.005	0.000
Lead	46	<0.020	<0.001	<0.002	0.001
Mercury	22	0.0012	<0.0002	<0.0003	0.0001
Nitrate (as N)	46	88.0	2.7	31.4	2.8
Dissolved oxygen	46	11.4	6.1	8.4	0.2
Phenols	46	0.007	<0.001	<0.002	0.000
Total dissolved solids	46	1300	260	773	33
Total suspended solids	46	100	<5	<8	2
Selenium	43	<0.0020	<0.0004	<0.0019	0.0001
Thallium	43	<0.001	<0.001	<0.001	0.000
pH, standard units	45	8.0	6.8	*b*	0.0,
Aluminum	46	3.79	<0.01	<0.41	0.12
Barium	46	0.1420	0.0393	0.0764	0.0028
Beryllium	46	<0.0004	<0.0001	<0.0002	0.0000
Boron	46	0.107	0.018	0.063	0.003
Calcium	46	310.0	40.1	172	8.3,
Cerium	46	<0.02	<0.02	<0.02	0.00
Cobalt	46	0.003	<0.002	<0.002	0.000
Copper	46	0.006	<0.002	<0.003	0.000
Gallium	46	<0.02	<0.01	<0.01	0.00
Iron	46	4.41	<0.02	<0.30	0.11
Lanthanum	5	<0.003	<0.003	<0.003	0.000
Lithium	46	0.028	0.002	<0.016	0.001
Magnesium	46	49.7	6.0	24.5	1.3,
Manganese	46	0.150	0.026	0.073	0.004
Molybdenum	46	<0.006	<0.006	<0.006	0.000
Nickel	46	0.238	<0.007	<0.012	0.005
Niobium	46	<0.01	<0.01	<0.01	0.00
Phosphorus	46	0.74	0.05	<0.12	0.02
Potassium	46	10.3	2.4	5.5	0.2
Scandium	46	0.001	<0.0004	<0.0004	0.0000
Silver	46	0.008	<0.004	<0.005	0.000
Sodium	46	170.0	11.45	8.7	4.6
Strontium	46	0.773	0.121	0.422	0.018
Thorium	46	<0.01	<0.01	<0.01	0.00
Titanium	46	0.046	<0.002	<0.008	0.001
Vanadium	46	0.009	<0.004	<0.004	0.000
Zinc	46	0.077	<0.001	<0.013	0.002
Zirconium	46	<0.010	<0.002	<0.004	0.001
PCB, total	46	<0.0005	<0.0005	<0.0005	0.0000
Volatile organics, total	46	0.048	<0.010	<0.011	0.001

[a]See Fig. 3.1.
[b]Not applicable.

Table 3.13. 1990 Y-12 annual summary for Upper Bear Creek nonradiological data (km 11.97)[a]

Parameter	Number of samples	Concentration (mg/L)			Standard error
		Max	Min	Av	
Arsenic	51	<0.040	<0.001	<0.007	0.001
Cadmium	50	0.0300	<0.0001	<0.0064	0.0011
Chromium	51	0.0480	<0.0010	<0.0044	0.0011
Cyanide	51	0.034	<0.002	<0.006	0.001
Lead	51	<0.020	<0.001	<0.002	0.001
Mercury	27	0.0009	<0.0002	<0.0002	0.0000
Nitrate (as N)	51	860.0	7.8	150.1	22.1
Dissolved oxygen	51	12.1	7.0	9.5	0.2
Phenols	51	0.006	<0.001	<0.002	0.000
Total dissolved solids	51	3000	330	1318	97
Total suspended solids	51	120	<5	<13	3
Selenium	48	<0.002	<0.0004	<0.002	0.000
Thallium	48	<0.005	<0.001	<0.001	0.000
pH, standard units	50	8.3	6.9	*b*	0.0
Aluminum	51	5.77	<0.04	<0.54	0.14
Barium	51	1.060	0.110	0.481	0.032
Beryllium	51	<0.0005	<0.0001	<0.0002	0.0000
Boron	51	0.183	0.011	0.050	0.004
Calcium	51	439	57	242	15
Cerium	51	<0.02	<0.02	<0.02	0.00
Cobalt	51	<0.010	<0.002	<0.003	0.000
Copper	51	<0.010	<0.002	<0.004	0.000
Gallium	51	<0.02	<0.01	<0.01	0.00
Iron	51	6.31	<0.02	<0.39	0.14
Lanthanum	5	<0.003	<0.003	<0.003	0.000
Lithium	51	0.030	<0.001	<0.011	0.001
Magnesium	51	61.8	8.8	33.5	2.2
Manganese	51	3.900	0.367	1.726	0.134
Molybdenum	51	<0.030	<0.006	<0.006	0.000
Nickel	50	0.222	0.009	0.044	0.005
Niobium	51	<0.05	<0.01	<0.01	0.00
Phosphorus	51	0.60	<0.05	<0.11	0.01
Potassium	51	8.6	2.2	5.0	0.2
Scandium	51	<0.0020	<0.0004	<0.0005	0.0000
Silver	51	<0.020	<0.004	<0.005	0.000
Sodium	51	76.5	10.2	37.6	2.4
Strontium	51	1.370	0.176	0.714	0.044
Thorium	51	<0.05	<0.01	<0.01	0.00
Titanium	51	0.080	<0.002	<0.009	0.002
Vanadium	51	0.020	<0.004	<0.004	0.000
Zinc	51	0.042	<0.001	<0.010	0.001
Zirconium	51	<0.010	<0.002	<0.005	0.001
PCB, total	51	<0.0050	<0.0005	<0.0006	0.0001
Volatile organics, total	51	0.098	<0.010	<0.012	0.002

[a]See Fig. 3.1.
[b]Not applicable.

Table 3.14. 1990 Y-12 annual summary for Station 17 nonradiological data[a]

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error
Mercury	508	0.0057	0.0002	0.0017	0.00004
Nitrate (as N)	109	6.9	2.2	4.8	0.08
Total phosphorus	109	0.82	0.13	0.33	0.009
Copper	106	0.014	<0.005	<0.008	0.0002
Zinc	109	0.1	0.026	0.055	0.0016
Chromium	109	<0.006	<0.006	<0.006	0.0
Molybdenum	109	0.179	<0.006	<0.042	0.003
Lithium	109	0.184	<0.001	<0.033	0.002
Selenium	90	<0.002	<0.0004	<0.002	0.00002
Cadmium	109	<0.004	<0.003	<0.004	0.00005
Lead	108	0.02	<0.001	<0.020	0.0002
Nickel	109	0.2	<0.007	<0.010	0.002
Calcium	109	79.6	40.2	62.2	0.81
Magnesium	109	14.5	6.59	11.7	0.153
Sodium	109	81.4	7.22	27.6	1.7
Potassium	109	3.8	0.45	2.51	0.05
Sulfate	109	220.0	39.0	92.0	3.5
Chloride	109	210.0	8.2	22.3	1.8
Fluoride	109	7.7	0.24	0.99	0.07
Total suspended solids	109	41.0	<5.0	<12.4	0.9
Total dissolved solids	109	600.0	94.0	320.0	7.5
Alkalinity	109	150.0	72.0	110.5	1.16
Total organic carbons	109	305.0	<2.0	<16.4	2.8
Residual chlorine, tot.	103	0.1	<0.1	<0.1	0.0
Cadmium (AA)	94	0.0021	<0.0001	<0.0007	0.00003
Temperature, °C	294	22.2	9.4	21.2	0.135
pH, standard units	290	8.6	3.7	*b*	0.024
Dissolved oxygen	289	9.2	0.4	5.4	0.095
Conductivity, mhos/cm	293	97.0	5.4	55.6	0.89

[a]Flow during operations and/or discharging.
[b]Not applicable.

Table 3.15. 1990 annual nonradiological summary for West End Sewer—Y-12 Plant

Parameter	Number of samples	Concentration[a]			
		Max	Min	Av	Standard error
Mercury	12	0.0160	<0.002	<0.0037	0.0013
Oil and grease	12	320.0	<2	<30.36	26.34
Total suspended solids	12	170.0	<5	<68.42	12.8
Cyanide	12	0.040	<0.002	<0.0108	0.0039
Ammonia	12	16.0	0.2	10.3	1.18
Kjeldahl nitrogen	12	23	0.42	14.03	1.84
Selenium	12	0.0030	<0.0004	<0.0020	0.0002
Biochemical oxygen demand	10	99.0	24.0	69.6	9.12
Chemical oxygen demand	12	300.0	7.0	141.0	23.28
Chromium +6	12	0.01	<0.01	<0.01	0.00
pH, standard units	12	8.40	6.80	*b*	0.123
Aluminum	12	0.71	0.09	0.26	0.048
Arsenic	12	<0.04	<0.04	<0.04	0.00
Barium	12	0.1120	0.0418	0.0604	0.0053
Beryllium	12	<0.0004	<0.0001	<0.0002	0.0
Boron	12	0.0430	0.0130	0.0298	0.0025
Cadmium	12	<0.004	<0.003	<0.003	0.0001
Calcium	12	58.9	38.7	46.2	1.88
Cerium	12	<0.02	<0.02	<0.02	0.00
Chromium	12	<0.006	<0.006	<0.006	0.00
Cobalt	12	0.002	<0.002	<0.002	0.00
Copper	12	0.026	<0.002	<0.014	0.0019
Gallium	12	<0.02	<0.01	<0.013	0.0014
Iron	12	0.900	0.240	0.456	0.0697
Lanthanum	1	0.003	<0.003	<0.003	0.00
Lead	12	<0.02	<0.02	<0.02	0.00
Lithium	12	0.020	<0.002	<0.0123	0.0019
Magnesium	12	12.70	8.23	11.05	0.3559
Mangenese	12	0.298	0.051	0.115	0.0225
Molybdenum	11	0.007	<0.006	<0.0062	0.0001
Nickel	12	<0.008	<0.007	<0.0073	0.0001
Niobium	12	<0.01	<0.01	<0.01	0.0000
Phosphorus	12	5.40	<0.12	<2.71	0.3694
Potassium	12	8.8	2.2	6.9	0.5190
Scandium	12	<0.0004	<0.0004	<0.0004	0.0000
Silver	12	0.008	<0.0004	<0.0052	0.0004
Sodium	12	43.0	12.8	18.5	2.3149
Strontium	12	0.1490	0.0949	0.1131	0.0044
Thorium	12	<0.01	<0.01	<0.01	0.0000
Titanium	12	0.010	<0.002	<0.0061	0.0011
Vanadium	12	<0.004	<0.004	<0.004	0.0000
Zinc	12	0.4160	0.0390	0.1923	0.0311
Zirconium	12	<0.01	<0.002	<0.005	0.0011

[a]All units are in mg/L unless noted otherwise.

Table 3.16. 1990 annual nonradiological summary for East End Sewer Y-12 Plant

Parameter	Number of samples	Concentration[a]			
		Max	Min	Av	Standard error
Mercury	12	0.0070	0.0003	0.0015	0.0005
Oil and grease	12	85.0	<2	<12.08	6.75
Total suspended solids	12	130.0	15	52.1	10.8
Cyanide	12	0.0290	<0.002	<0.0096	0.0026
Ammonia	12	13.0	4.2	8.2	0.82
Kjeldahl nitrogen	12	18	2.4	13.7	1.26
Selenium	12	0.0020	<0.0004	<0.0019	0.0001
Biochemical oxygen demand	10	57.0	21.0	35.9	4.22
Chemical oxygen demand	12	320.0	45.0	120.3	21.0
Chromium +6	12	0.08	<0.01	<0.02	0.006
pH, standard units	12	7.8	7.1	*b*	0.07
Aluminum	12	0.4	0.1	0.24	0.03
Arsenic	12	<0.04	<0.04	<0.04	0.00
Barium	12	0.0628	0.0327	0.0476	0.0028
Beryllium	12	<0.0004	<0.0001	<0.0002	0.0
Boron	12	0.041	0.019	0.031	0.0019
Cadmium	12	<0.004	<0.003	<0.003	0.0001
Calcium	12	50.3	37.6	42.9	1.1
Cerium	12	<0.02	<0.02	<0.02	0.00
Chromium	12	<0.006	<0.006	<0.006	0.00
Cobalt	12	0.002	<0.002	<0.002	0.00
Copper	12	0.028	0.007	0.019	0.002
Gallium	12	<0.01	<0.01	<0.01	0.00
Iron	12	0.71	0.10	0.37	0.06
Lanthanum	1	0.003	<0.003	<0.003	0.00
Lead	12	<0.02	<0.02	<0.02	0.00
Lithium	12	0.020	<0.001	<0.010	0.02
Magnesium	12	12.10	9.57	10.61	0.185
Mangenese	12	0.112	0.027	0.053	0.008
Molybdenum	11	0.033	<0.006	<0.011	0.0024
Nickel	12	0.008	<0.007	<0.007	0.0001
Niobium	12	<0.01	<0.01	<0.01	0.0000
Phosphorus	12	4.80	1.95	3.08	0.264
Potassium	12	10.1	4.6	6.5	0.41
Scandium	12	<0.0004	<0.0004	<0.0004	0.0000
Silver	12	0.031	<0.004	<0.011	0.0026
Sodium	12	24.6	11.5	16.0	1.1
Strontium	12	0.1550	0.0958	0.1080	0.0046
Thorium	12	<0.01	<0.01	<0.01	0.0000
Titanium	12	0.010	<0.002	<0.006	0.001
Vanadium	12	<0.004	<0.004	<0.004	0.0000
Zinc	12	0.369	0.089	0.199	0.0263
Zirconium	12	<0.01	<0.002	<0.005	0.0011

[a]All units are in mg/L unless noted otherwise.

level, where available. (See Tables 4.1–4.3 in Vol. 2 for levels.) Inorganic compounds were all below the national primary drinking water regulation levels. The average concentration of manganese at MHD and WOCH were 292% and 243% of the national secondary drinking water limit, which is 0.05 mg/L. High manganese concentrations are commonly associated with the geology of this area. Analytical results for arsenic, selenium, and manganese are represented by two lines in the table; the first line is ICP data and the second line is AA data. The AA results have detection limits that are below the regulatory limits, and the data have better accuracy and precision for these analyses. These data show that the drinking water standards for arsenic and selenium are not being exceeded.

K-25 Site

Tables 3.3 through 3.9 in Vol. 2 give the water quality parameter data for the ambient surface water surrounding the K-25 Site. Figure 3.5 depicts the sampling locations. The K-25 Site does not appear to affect any parameters when data from Poplar Creek and Clinch River, both upstream and downstream from the site, are compared.

Mitchell Branch has been designated by TDC as a biologically impacted stream. Sources of these impacts have been identified as (1) residual chlorine and temperature from once-through cooling with sanitary water, (2) process discharges with high levels of total dissolved solids, and (3) organic contaminants from groundwater. Ambient data from Mitchell Branch sources (Table 3.9 in Vol. 2) must be compared with K-1700 NPDES monitoring (Table 3.74 in Vol. 2) to review the impact of plant streams on Mitchell Branch water quality. Several FY 1990 projects that address the toxicity of these sources to Mitchell Branch are being pursued. The objective of these projects is to remove K-25 Site discharges from Mitchell Branch or render the discharges nontoxic. Stream recovery should follow the completion of these projects.

3.2 NPDES MONITORING PROGRAM

Under the requirements of the CWA, an NPDES permit has been issued to each of the three Oak Ridge facilities. There are as many as six components to the NPDES permit at the Oak Ridge plants. Each plant is required to develop a radiological sampling plan specific to its problems. The NPDES permit for each plant is unique and outlines specific outfalls and sampling locations, parameters, and frequencies for analysis for all nonradiological parameters. It may also list permit compliance limits to ensure environmental protection. Table 3.10 in Vol. 2 lists the outfall number or designation for each of the Oak Ridge facilities and gives a brief description of the location. Other components of the permit include requirements for the toxicity control and monitoring program (TCMP), the biological monitoring and abatement program (BMAP), a mercury assessment plan, and a PCB sampling plan for aquatic pathways. Tables 3.18, 3.19, and 3.20 detail the permit requirements and compliance records at each outfall during 1990. Within the last few years, the NPDES permit requirements have changed. Biological monitoring has become a major component of environmental compliance programs at the Y-12 Plant, ORNL, and the K-25 Site. The recent emphasis on biological monitoring by regulatory agencies, as reflected in the draft permit issued to the K-25 Site by TDC, indicates a shift to a biological monitoring–based policy that emphasizes impacts on the receiving waters in addition to use of best available technology (BAT). Biological monitoring at the three Oak Ridge facilities also provides the framework for the establishment of interim, less restrictive effluent limits until new wastewater treatment facilities and other remedial actions are completed and water quality standards can be met.

NPDES permits issued in 1984 and a permit modification issued in 1986 under Sect. 402 of the CWA required implementation of a BMAP at each of the three facilities. The BMAPs were developed by ORNL's Environmental Sciences Division (ESD) staff and consist of four major tasks: (1) ambient toxicity testing, (2) bioaccumulation studies, (3) biological indicator studies that include measurement of selected biochemical parameters and histopathological analyses, and (4) benthic invertebrate and fish community surveys. These tasks use techniques ranging from laboratory bioassays and manipulative field experiments to routine biotic surveys to assess ecological effects at different levels of biological organization.

These programs were developed to meet two major objectives. First, biological monitoring will be

Table 3.17. 1990 surface water analyses at reference locations

Parameter	Number of samples	Concentration (mg/L)				% DWL[b]
		Max	Min	Av	Standard error[a]	
Melton Hill Dam[c]						
Aluminum, total	12	2.6	<0.030	<0.68	0.22	
Antimony, total	12	0.078	<0.050	<0.052	0.0023	
Arsenic, ICP	12	<0.050	<0.050	<0.050	0	<100
Arsenic, AA	5	<0.010	<0.010	<0.010	0	<20
Barium, total	12	0.071	<0.0010	<0.034	0.0047	<3.3
Beryllium, total	12	<0.010	<0.0002	<0.0011	0.00081	
Boron, total	12	<0.080	<0.080	<0.080	0	
Cadmium, total	12	<0.020	<0.0040	<0.0065	0.0013	<65
Calcium, total	12	41	35	37	0.63	
Chromium, total	12	<0.050	<0.0040	<0.0089	0.0038	<17
Cobalt, total	12	<0.0040	<0.0040	<0.0040	0	
Copper, total	12	<0.050	<0.0050	<0.012	0.0036	<1.2
Dissolved solids, total	12	480	130	190	27	
Fluoride, total	12	<1.0	<1.0	<1.0	0	
Iron, total	12	2.1	<0.050	<0.59	0.18	<197
Lead, total	12	<0.050	<0.030	<0.047	0.0022	<93
Lithium, total	12	<15	<15	<15	0	
Magnesium, total	12	11	8.3	9.6	0.24	
Manganese, ICP	12	0.49	0.011	0.15	0.044	292
Manganese, AA	5	0.56	0.0060	<0.13	0.11	<250
Molybdenum, total	12	<0.040	<0.040	<0.040	0	
Nickel, total	12	<0.050	<0.0040	<0.010	0.0038	
Nitrate	12	<5.0	<5.0	<5.0	0	<50
Oil and grease	12	69	<2.0	<8.3	5.6	
Organic carbon, total	12	5.8	1.6	2.4	0.35	
Phosphorus, total	12	1.8	<0.30	<0.43	0.13	
Selenium, ICP	12	<0.050	<0.040	<0.048	0.0013	<475
Selenium, AA	5	0.0050	<0.0020	<0.0044	0.00060	<44
Silicon, total	12	5.9	1.5	3.2	0.36	
Silver, total	12	<0.020	<0.0050	<0.0063	0.0013	<12
Sodium, total	12	5.5	4.2	5.0	0.082	
Strontium, total	12	0.10	0.073	0.090	0.0023	
Sulfate as SO_4	12	30	17	22	1.2	8.9
Suspended solids, total	12	73	<5.0	<19	5.5	
Tin, total	12	<0.050	<0.050	<0.050	0	
Titanium, total	12	0.053	<0.020	<0.023	0.0027	
Vanadium, total	12	0.0042	<0.0020	<0.0029	0.00030	
Zinc, total	12	<0.050	<0.0050	<0.014	0.0037	<0.27
Zirconium, total	12	<0.020	<0.020	<0.020	0	
Conductivity, mS/cm	12	1.7	0.10	0.73	0.16	
Oxygen, dissolved	12	13	7.0	9.4	0.51	
Temperature, °C	12	23	8.0	16	1.5	
Turbidity, JTU	12	170	3.0	39	14	
pH, standard units	12	8.6	7.2	7.7	0.13	

Table 3.17 (continued)

Parameter	Number of samples	Concentration (mg/L)				% DWL[b]
		Max	Min	Av	Standard error[a]	
			White Oak Creek Headwaters[c]			
Aluminum, total	12	4.8	<0.030	<0.70	0.39	
Antimony, total	12	0.074	<0.050	<0.052	0.0020	
Arsenic, ICP	12	<0.05	<0.05	<0.05	0	<100
Arsenic, AA	5	<0.01	<0.01	<0.01	0	<20
Barium, total	12	0.13	<0.0010	<0.060	0.0099	<5.9
Beryllium, total	12	<0.010	<0.0002	<0.0011	0.00081	
Boron, total	12	<0.080	<0.080	<0.080	0	
Cadmium, total	12	<0.020	<0.0040	<0.0065	0.0013	<65
Calcium, total	12	31	13	23	1.7	
Chromium, total	12	<0.050	<0.0040	<0.0091	0.0037	<18
Cobalt, total	12	0.0061	<0.0040	<0.0042	0.00018	
Copper, total	12	<0.050	<0.0050	<0.010	0.0037	<1.0
Dissolved solids, total	12	160	67	100	8.3	
Fluoride, total	12	<1.0	<1.0	<1.0	0	
Iron, total	12	5.3	<0.010	<0.77	0.42	<257
Lead, total	12	<0.050	<0.030	<0.047	0.0022	<93
Lithium, total	12	<15	<15	<15	0	
Magnesium, total	12	14	6.3	11	0.84	
Manganese, ICP	12	0.97	<0.0020	<0.12	0.078	<243
Manganese, AA	5	0.17	<0.010	<0.071	0.034	<141
Molybdenum, total	12	<0.040	<0.040	<0.040	0	
Nickel, total	12	<0.050	<0.0040	<0.010	0.0038	
Nitrate	12	10	<1.0	<5.1	0.56	<50
Oil and grease	12	2.0	<2.0	<2.0	0	
Organic carbon, total	12	2.0	0.70	1.1	0.10	
Phosphorus, total	12	<0.30	<0.30	<0.30	0	
Selenium, ICP	12	<0.050	<0.040	<0.048	0.0013	<475
Selenium, AA	5	<0.0050	<0.0020	<0.0044	0.00060	<44
Silicon, total	12	8.4	3.2	4.1	0.41	
Silver, total	12	<0.020	<0.0050	<0.0063	0.0013	<12
Sodium, total	12	<5.0	<2.0	<4.8	0.25	
Strontium, total	12	0.034	0.017	0.026	0.0017	
Sulfate as SO_4	12	<5.0	<5.0	<5.0	0	<2.0
Suspended solids, total	12	340	<5.0	<41	27	
Tin, total	12	<0.050	<0.050	<0.050	0	
Titanium, total	12	0.045	<0.020	<0.022	0.0021	
Vanadium, total	12	0.0085	<0.0020	<0.0031	0.00056	
Zinc, total	12	<0.050	<0.0050	<0.013	0.0044	<0.26
Zirconium, total	12	<0.020	<0.020	<0.020	0	
Conductivity, mS/cm	12	1.7	0	0.57	0.19	
Oxygen, dissolved	12	12	6.7	9.6	0.52	
Temperature, °C	12	20	8.6	13	1.1	
Turbidity, JTU	12	170	8.0	44	14	
pH, standard units	12	8.0	6.8	7.4	0.11	

[a]Standard error of the mean.
[b]Average concentration as a percentage of National Primary or Secondary Drinking Water Regulation level.
[c]See Fig. 3.4.

Table 3.18. 1990 NPDES compliance at the Y-12 Plant

Discharge point	Effluent parameter	Effluent limits: Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)	Percent of compliance	Number of samples
301 (Kerr Hollow Quarry)	Lithium				5.0	100	14
	pH (standard units)			*a*	8.5	100	14
	Total suspended solids			30.0	50.0	100	13
	Temperature (°C)				30.5	100	14
	Zirconium				3.0	100	14
302 (Rogers Quarry)	Oil and grease			10.0	15.0	98	52
	pH (standard units)			*a*	8.5	83	52
	Settleable solids (mL/L)				0.5	100	52
	Total suspended solids			30.0	50.0[b]	100	52
	Temperature (°C)				30.5	100	52
304 (Bear Creek)	Oil and grease			10.0	15.0	98	52
	pH (standard units)			*a*	8.5	100	73
305 ILSF	Oil and grease			>10.0	<15.0	100	8
	pH (standard units)			*a*	8.5	88	8
	Total suspended solids			30.0	50.0	100	8
307 (West Borrow Area)	Temperature (°C)					100	4
	pH (standard units)					100	4
	Oil and grease					100	4
	Total suspended solids					100	4
308 (East Borrow Area)	Temperature (°C)					100	4
	pH (standard units)					100	4
	Oil and grease					100	4
	Total suspended solids					100	4
501 [Central Pollution Control Facility (CPCF-I)]	Cadmium, total	0.07	0.19	0.26	0.69	100	45
	Chromium, total	0.5	0.75	1.71	2.77	100	45
	Copper, total	0.6	0.9	2.07	3.38	100	45
	Cyanide, total	0.2	0.33	0.65	1.20	100	45
	Lead, total	0.12	0.19	0.43	0.69	100	45
	Nickel, total	0.65	1.1	2.38	3.98	100	45
	Oil and grease	7.1	14.2	26.0	52.0	96	45
	pH (standard units)			*a*	9.0	98	46
	Silver, total	0.07	0.12	0.24	0.43	100	45
	Temperature (°C)				30.5	100	45
	Total suspended solids	8.5	16.4	31.0	60.0	96	45
	Total toxic organics		0.6		2.13	100	45
	Zinc, total	0.4	0.7	1.48	2.61	100	45
502 West End Treatment Facility (WETF)	Cadmium, total	0.07	0.019	0.26	0.69	100	83
	Chromium, total	0.50	0.75	1.71	2.77	100	83
	Copper, total	0.60	0.92	2.07	3.38	100	83
	Cyanide, total	0.2	0.33	0.65	1.20	99	80
	Lead, total	0.12	0.19	0.43	0.69	100	83
	Nickel, total	0.65	1.10	2.38	3.98	99	83
	Oil and grease	7.1	14.2	26.0	52.0	99	77
	pH (standard units)			*a*	9.0	100	78
	Silver, total	0.07	0.12	0.24	0.43	100	83
	Temperature (°C)				30.5	100	78
	Total suspended solids	8.5	16.4	31.0	60.0	89	83
	Total toxic organics		0.6		2.13	100	26
	Zinc, total	0.4	0.7	1.48	2.61	100	83

Table 3.18 (continued)

Discharge point	Effluent parameter	Effluent limits: Daily av (kg/d)	Effluent limits: Daily max (kg/d)	Effluent limits: Daily av (mg/L)	Effluent limits: Daily max (mg/L)	Percent of compliance	Number of samples
503 (Steam Plant Wastewater Treatment Facility)	Chromium, total	0.38	0.38	0.20	0.20	100	158
	Copper, total	1.89	1.89	1.0	1.0	100	158
	Iron, total	1.89	1.89	1.0	1.0	97	158
	Zinc, total	1.89	1.89	1.0	1.0	100	158
	Oil and grease	28.4	37.9	15.0	20.0	100	156
	Total suspended solids	57.0	189.0	30.0	100.0	100	157
	Temperature (°C)				30.5	100	159
	pH (standard units)			*a*	9.0	99	159
Category I outfalls (precipitation runoff and small amounts of groundwater)	pH (standard units)			*a*	8.5	100	13
Category II outfalls (cooling waters, condensate, precipitation runoff, and building, roof, and foundation drains)	pH (standard units)			*a*	8.5	100	90
	Temperature[c] (°C)					100	90
Category III outfalls (process wastewaters)	pH (standard units)			*a*	8.5	100	47
Category IV outfalls (untreated process wastewaters)	pH (standard units)			*a*	8.5	99	288
504 Plating Rinsewater Treatment Facility	Cadmium, total	0.07	0.019	0.26	0.69	100	20
	Chromium, total	0.50	0.75	1.71	2.77	100	20
	Copper, total	0.60	0.92	2.07	3.38	100	20
	Cyanide, total	0.2	0.33	0.65	1.20	100	20
	Lead, total	0.12	0.19	0.43	0.69	100	20
	Nickel, total	0.65	1.10	2.38	3.98	100	20
	Oil and grease	7.1	14.2	26.0	52.0	100	20
	pH (standard units)			*a*	9.0	100	20
	Silver, total	0.07	0.12	0.24	0.43	100	20
	Temperature (°C)				30.5	100	20
	Total suspended solids	8.5	16.4	31.0	60.0	100	20
	Total, toxic organics		0.6		2.13	100	20
	Zinc, total	0.4	0.7	1.48	2.61	100	20
501/504 (Combined discharge Central Pollution Control Facility and Plating Rinse Water Treatment Facility)	Cadmium, total	0.07	0.019	0.26	0.69	100	8
	Chromium, total	0.50	0.75	1.71	2.77	100	8
	Copper, total	0.60	0.92	2.07	3.38	100	8
	Cyanide, total	0.2	0.33	0.65	1.20	100	8
	Lead, total	0.12	0.19	0.43	0.69	100	8
	Nickel, total	0.65	1.10	2.38	3.98	100	8
	Oil and grease	7.1	14.2	26.0	52.0	100	8
	pH (standard units)			*a*	9.0	100	8
	Silver, total	0.07	0.12	0.24	0.43	100	8
	Temperature (°C)				30.5	100	8
	Total suspended solids	8.5	16.4	31.0	60.0	100	8
	Total toxic organics		0.6		2.13	100	8
	Zinc, total	0.4	0.7	1.48	2.61	100	8

Table 3.18 (continued)

Discharge point	Effluent parameter	Effluent limits: Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)	Percent of compliance	Number of samples
623 (Steam Plant fly ash sluice water)	pH (standard units)			*a*	8.5	82	44
506 (9204-3 sump pump oil)	Temperature (°C)				30.5	98	54
	Oil and grease			10.0	15.0	100	53
	pH (standard units)			*a*	8.5	100	53
508 (Experimental mobile wastewater treatment facility)	Mercury, total			0.002	0.004	*d*	*a*
	pH (standard units)			*a*	9.0	*d*	
	Total suspended solids			30.0	45.0	*d*	
510 (Waste Coolant Processing Facility)	Biochemical oxygen demand	1.33	2.65			*d*	
	Oil and grease			15.0	20.0	*d*	
	pH (standard units)			*a*	9.0	*d*	
	Temperature (°C)				30.5	*d*	
	Total suspended solids			30.0	50.0	*d*	
Miscellaneous discharges (cooling tower blowdown)	Chromium, total				1.0	100	56
	Copper, total			0.5	1.0	100	57
	Free available chlorine			0.2	0.5	98	56
	pH (standard units)			*a*	8.5	96	56
	Temperature (°C)			35	38	100	56
	Zinc, total			0.5	1.0	100	57
Miscellaneous discharges (demineralizers)	pH (standard units)			*a*	8.5	*d*	
	Total suspended solids			30	50	*d*	

[a]Not applicable.
[b]Limit not applicable during periods of increased surface runoff resulting from precipitation.
[c]Temperature shall be controlled such that the stream temperature standards delineated in the General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee, as amended, are not violated as a result of this discharge.
[d]No discharge.

Table 3.19. 1990 NPDES compliance at ORNL

Discharge point	Effluent parameters	Discharge limitations: Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Number of noncompliances	Percent of compliance
X01 (Sewage Treatment Plant)	Biochemical oxygen demand (summer)	8.7	13.1	10	15	0	100
	Biochemical oxygen demand (winter)	17.4	26.2	20	30	0	100
	Total suspended solids	26.2	39.2	30	45	2	98.7
	Ammonia (N) (summer)	3.5	5.2	4	6	0	100
	Ammonia (N) (winter)	7.8	11.8	9	13.5	0	100
	Oil and grease	8.7	13.1	10	15	8	94.9
	Dissolved oxygen				6.0[a]	1	99.6
	pH (standard units)					0	100.6
	Residual chlorine				0.5	1	99.4
	Fecal coliform, geometric mean			1000[b]	5000[b]	1	99.4
X02 (Coal Yard Runoff Treatment Facility)	Temperature, °C				30.5	0	100
	Total suspended solids				50	1	98.1
	Oil and grease			15.0	20.0	2	96.2
	Chromium, total			0.2	0.2	0	100
	Copper, total			1.0	1.0	0	100
	Iron, total			1.0	1.0	1	98.2
	pH (standard units)					3	98.8
	Zinc			1.0	1.0	0	100
X06A (1500 and 2000 Areas, and 3539 and 3540 Ponds)	pH (standard units)					0	100
X07 (Process Waste Treatment Plant-3544)	pH (standard units)					0	100
X09A (REDC/HFIR)	pH (standard units)					0	100
X11 (Acid Neutralization Facility)	pH (standard units)					0	100

Table 3.19 (continued)

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent of compliance
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)		
X12 (Nonradiological Wastewater Treatment Facility)	Temperature, °C				30.5	0	100
	Total suspended solids	93.9	182	31	60	0	100
	Oil and grease	30.3	45.4	10	15	0	100
	Total toxic organics		6.45		2.13		
	Cyanide, total	1.97	3.64	0.65	1.20	0	100
	Cadmium, total	0.79	2.09	0.26	0.69	0	100
	Chromium, total	5.18	8.39	1.71	2.77	0	100
	Copper, total	6.27	10.24	2.07	3.38	0	100
	Lead, total	1.30	2.09	0.43	0.69	0	100
	Nickel, total	7.21	12.06	2.38	3.98	0	100
	pH (standard units)					0	100
	Silver, total	0.73	1.30	0.24	0.43	0	100
	Zinc, total	4.48	7.91	1.48	2.61	0	100
Category I	Oil and grease			10	15	6	60
	pH (standard units)					0	100
	Temperature, °C				30.5	0	100
	Total suspended solids			30	50	6	72.7
Category II	Oil and grease			10	15	20	88.4
	pH (standard units)					0	100
	Total suspended solids			30	50	22	87.7
Category III	pH (standard units)					0	100
Steam Plant (SP2519)	pH (standard units)					1	75
	Temperature, °C			35	38	0	100
Vehicle cleaning (VC7002)	Biochemical oxygen demand			30	45	2	0
	Fecal coliform			200[b]		2	0
	Oil and grease			10	15	2	0
	pH (standard units)					0	100
	Phenols			1.0	2.0	0	100
	Total suspended solids			25	40	2	0

Table 3.19 (continued)

Discharge point	Effluent parameters	Discharge limitations				Number of noncompliances	Percent of compliance
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)		
Equipment Maintenance Facility (EF7002)	Oil and grease				15	1	0
	pH (standard units)					1	0
Cooling systems	Chlorine				0.2	4	91.8
	Chromium				1.0	0	100
	Copper			0.5	1.0	1	98.1
	Temperature, °C			35	38	1	98.1
	Zinc			0.5	1.0	2	96.3
	pH (standard units)					0	100

[a]Minimum.

[b]Colonies per 100 mL.

Note: The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units. It shall be monitored by (1) a weekly grab sample taken at the effluent for discharge points X01, X02, X06A, X07 and X11; (2) a per discharge grab sample taken at the effluent for discharge point X09A; (3) a monthly grab sample taken at the effluent for discharge points X13, X14, and X15; (4) once per year by a grab sample taken at each of the Category I outfalls; (5) once per quarter by a grab sample taken at the effluent for pH at each of the Category II outfalls; (6) once per quarter by a grab sample taken at the effluent for pH at each of the Category III outfalls; (7) once per quarter at EF7002; (8) once per month at VC7002; and (9) once per quarter at SP2519. At the same time, a sample will be taken in the stream immediately downstream of every discharge point except X13, X14, X15, Category III outfalls, EF7002, VC7002, and SP2519. There are no numeric limits for downstream pH; however, the state has maintained that the downstream pH shall not be less than 6.5 standard units nor greater than 8.5 standard units.

Table 3.20. 1990 NPDES compliance at the K-25 Site

Discharge point	Effluent parameters	Effluent limits: Daily av (mg/L)	Daily max (mg/L)	Daily av (kg/d)	Daily max (kg/d)	Number of noncompliances	Percent compliance
001							
K-1700 discharge	Aluminum		1.0		16	7	93
	Chromium	0.050	0.080	0.80	1.2		100
	Nitrate (as N)		20		310		100
	Suspended solids[a]	30	50	470	780		100
	Oil and grease	10[b]	15	160	230		100
	pH, standard units		6.0–9.0				100
	Lead	0.0080	0.93	0.12	14		100
	Zinc	0.12	1.5	1.86	246		100
	Color		*c*				*d*
005							
(K-1203 sanitary treatment facility)[e]	Ammonia nitrogen	5.0	7.0	12	17.3		100
	BOD	15	20	37	49.5	0	100
	Chlorine, residual		0.24			1	99
	Dissolved oxygen	5.0[b]					100
	Fecal coliform, No./100 mL	200	400			0	100
	pH, standard units		6.0–9.0				100
	Suspended solids	30	45	74	110		100
	Settleable solids, mL/L		0.50			0	100
	Unpermitted discharge—untreated sewage	*d*	*d*	*d*	*d*	3	*d*
(K-1007-B holding pond)	COD	20	25	120	150	1	98
	Chromium, total		0.050		0.30	0	100
	Dissolved oxygen	5.0[b]				1	98
	Fluoride	1.0	1.5	6.1	9.1		100
	Oil and grease	10	15	61	91		100
	pH, standard units		6.0–9.0				100
	Suspended solids[a]	30	50	182	304		100
007							
(K-901-A holding pond)	Chromium, total		0.05		0.68		100
	Fluoride	1.0	1.5	4.2	6.3		100
	Oil and grease	10	15	42	63		100
	pH, standard units		6.0–10				100
	Suspended solids[a]	30	50	125	210	3	97
	Dissolved oxygen	5[b]					100
	Visible solids		*c*				*d*

Table 3.20 (continued)

Discharge point	Effluent parameters	Effluent limits				Number of noncom-pliances	Percent compliance
		Daily av (mg/L)	Daily max (mg/L)	Daily av (kg/d)	Daily max (kg/d)		
009							
(K-1515-C sanitary water plant)	Suspended solids[a]	30	50	34	51	1	98
	Aluminum	5.0	10	5.7	11	0	100
	Sulfate		1400		1600		100
	pH, standard units		6.0–9.0				
Storm drain	Unpermitted Discharge		*c*			5	*d*
011							
(K1407-J)[f,g]	Cadmium	0.26	0.69				100
	Chromium	1.71	2.77				100
	Copper	2.07	3.38				100
	Lead	0.43	0.69				100
	Silver	0.24	0.43				100
	Zinc	1.48	2.61				100
	Cyanide	0.65	1.20				100
	TTO		2.13				100
	Oil and grease	26	52				100
	Nickel	2.38	3.98				100
	TSS	31	60			0	100
	PCB, µg/L		0.014				
	pH, standard units		6.0–9.0				100
010							
(K-1407-E and K-1407-F)	Temperature		30.5				100
	TSS		50			0	100
	Oil and grease	15	20				100
	Chromium	0.2	0.2				100
	Copper	1.0	1.0				100
	Iron	1.0	1.0			4	92
	Zinc	1.0	1.0				100
	PCB (µg/L)		0.014				100
	pH, standard units		6.0–9.0				

[a]Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface runoff resulting from precipitation.

[b]Daily minimum.

[c]No discharge.

[d]Not applicable.

[e]Because of the small flow rates at the K-710-A sanitary treatment facility (discharge point W27), a rapid sand filter was installed May 1, 1978, eliminating the surface discharge and the need for monitoring.

[f]During the characterization of this effluent point more data are obtained and reported but are not subject to limits at this time.

[g]Permit limits for Discharge Point 011 are monthly averages.

Table 3.21. 1990 annual radiological summary in water around Y-12 Plant

Parameter	Number of samples	Concentration (pCi/L) Max	Min	Av	Standard error	% DCG
			Station 17			
Alpha activity	50	47	5	21	1.2	*a*
Beta activity	50	50	0.9	25	1.5	*a*
^{90}Sr	50	14	–5.74	0.26	0.48	0.03
^{237}Np	50	0.76	–1.12	0.17	0.04	0.58
^{226}Ra	46	<1.97	–0.38	<0.73	0.07	<0.73
^{228}Ra	45	<256	–3.2	<56	11	<56
			Bear Creek Outfall 304			
Alpha activity	54	250	2.2	26	5	*a*
Beta activity	54	640	2.4	46	12	*a*
^{90}Sr	19	5.5	–4.1	0.58	0.56	0.06
^{237}Np	6	0.23	0.02	0.12	0.03	0.39
^{226}Ra	2	1.81	0.172	0.87	0.36	0.87
^{228}Ra	2	<324	<1.26	<143	83	<143

[a]Not applicable.

used to demonstrate that the interim effluent limits established for each facility protect the classified uses of the receiving stream (e.g., growth and propagation of fish and aquatic life), as determined by TDC. A second objective is to evaluate the effects on stream biota resulting from construction and operation of major new pollution abatement facilities and other remedial actions.

Biomonitoring can be used to assess the effectiveness of these remedial actions through documentation of the process of ecological recovery.

Results of the biological monitoring programs at the three Oak Ridge facilities are discussed in Sect. 9.4.

3.2.1 Radiological summary

Y-12 Plant

Development of a radiological monitoring plan for the Y-12 Plant is dictated by the NPDES permit. This plan was developed and submitted to TDC for approval in 1987. Monitoring activities under this plan began during the third quarter of 1987.

The proposed plan addresses compliance with the NPDES permit and the "as low as reasonably achievable" (ALARA) philosophy for radioactive discharges in liquid effluents. The monitoring program is designed to monitor effluents at treatment facilities, other point and area source discharges, and in-stream locations. Known or suspected radioactive materials and indicator parameters are monitored. The treatment facilities that are monitored include the Central Pollution Control Facility (CPCF), the West End Treatment Facility (WETF), the Steam Plant Wastewater Treatment Facility (SPWTF), and the Plating Rinsewater Treatment Facility (PRTF) (Fig. 3.6). Point and area discharges that include outfall 109, Y-12 Plant area drainage; outfall 135, Y-12 Plant area drainage; outfall 147, cooling water drainage; outfall 305, oil retention pond number 1; and outfall 306, oil retention ponds numbers 1 and 2 have been closed under an approved RCRA closure plan. The in-stream location for 1990 was outfall 304, Bear Creek. These data are summarized in Table 3.21.

The radium data appear abnormal in proportion to other radionuclides because of the susceptibility of this radiochemical method to background noise. Activity counts in the spectral region for radium are influenced by naturally occurring radioactivity. Thus, although no radium peak is observed by gamma

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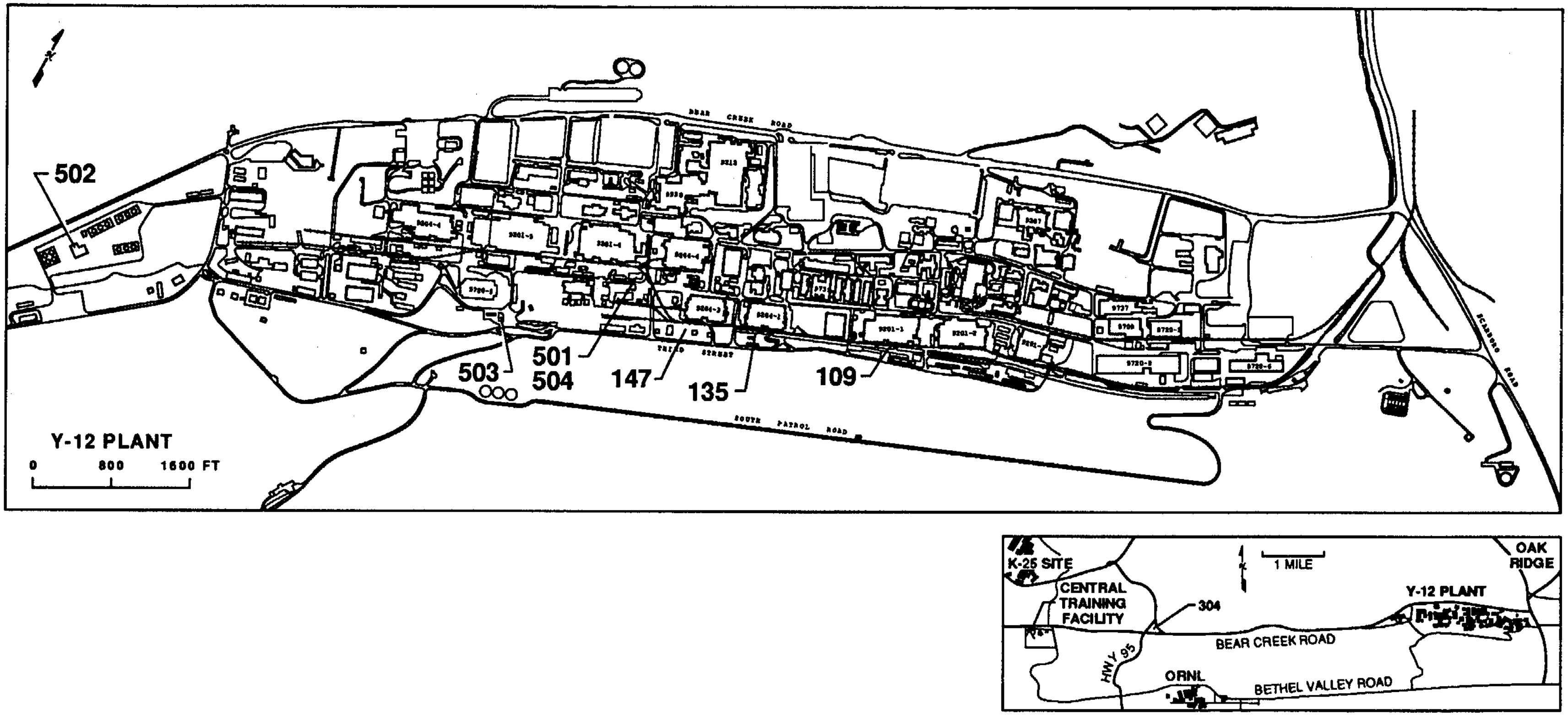

Fig. 3.6. Y-12 Plant NPDES radiological monitoring plan locations.

spectrometry, several activity counts are influenced by background.

DOE Order 5400.5 requires all DOE facilities to maintain radionuclide effluents at ALARA levels. Consistent with this policy, the Y-12 Plant will continue to operate in a manner that complements the ALARA philosophy. The Y-12 Plant ALARA program includes an aggressive plan to identify sources of radioactive discharges via various monitoring programs.

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ORNL's radiological sampling plan calls for monitoring many of the same locations as required in the permit for nonradiological monitoring. The schedule of parameters analyzed and frequencies of analysis currently observed is given in Table 3.7. Outfalls X06A, X07, X09A, and X11 were eliminated during the first quarter of 1990 as part of the implementation of the Nonradiological Wastewater Treatment Facility (NRWTF), which came online with compliance-level-attained on April 1, 1990. Changes in the sampling procedures were implemented during the first quarter of 1990. Effective in February, X09A (HFIR and REDC ponds), X06A (190 ponds, 1500 and 2000 areas), X11(3518), and X07(3544) effluents were redirected to the NRWTF. Table 3.11 in Vol. 2 gives a summary of radiological parameter concentrations for each location. The sample sizes and station names reflect the changes occurring during the year.

There are apparent discrepancies between the average concentrations reported in Tables 3.10 of this volume and 3.11 in Vol. 2 for MB1, WOC, and WOD. This is due to calculating flow-weighted averages for Table 3.10 and arithmetic averages for the table in Vol. 2. The flow-weighted average is a more accurate representation of contaminant concentration. Arithmetic averages are used when flow data are not available to weight the calculation of the mean. The following discussion uses the arithmetic average information because these numbers provide a consistent basis of comparison across all stations. Table 3.10 presents flow-weighted averages because the flow information is available.

Grab samples from Categories I (storm drains) and II (roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, cooling tower blowdown and condensate) outfalls are analyzed for gross beta activity. Category I outfalls are sampled annually, and Category II outfalls are sampled quarterly.

Average ^{60}Co concentration at X09A (3.5% DCG) was down from the 1989 level (30% DCG).

The stations where the average ^{137}Cs concentration exceeded 1% of the DCG were PWTP (57% DCG), NRWTF (26% DCG), WOC (4.6% DCG), and WOD (1.6% DCG). It appears that ^{137}Cs releases are primarily the result of process discharges. Except for NRWTF, which began operation in 1990, average concentrations of ^{137}Cs are comparable to those reported in 1989.

For comparison purposes, the DCG for ^{90}Sr was used to evaluate total radioactive strontium discharges. This is a conservative approach. Total radioactive strontium average concentration exceeded 1% of the DCG at MB1 (46%), PWTP (26%), WOD (20%), WOC (13%), STP (13%), and NRWTF (2.0%). Average concentrations found in Table 3.1 in Vol. 2 (discussed in Sect. 3.1, Surface Water Monitoring) that exceeded 1% of the DCG were First Creek (30%), 7500 bridge (6.2%), Northwest Tributary (4.5%), Fifth Creek (3.6%), and Raccoon Creek (2.9%). Unlike ^{60}Co and ^{137}Cs discharges, which are primarily process related, the total radioactive strontium releases are more diffuse and are probably more the result of past activities and subsurface input rather than discharges from process facilities. The observed 1990 concentrations are quite comparable to those observed in 1989. The calculated discharges at MB1, WOC, and WOD (Table 3.10) are also approximately those calculated in 1989.

The stations where the average ^{3}H concentration exceeded 1% of the DCG are MB1 (40%), WOD (9.6%), WOC (3.7%), and NRWTF (1.2%). Most of the tritium is believed to come from solid waste storage area (SWSA) 5. However, there is a process-related contribution from NRWTF.

Osmium-191 was observed in one first-quarter WOD surface water sample. This occurred at no other time in 1990. This observance coincides with process control difficulties at the medical isotope facility. Operations have been modified to alleviate releases to the environment.

A list of the Category I and II gross beta concentration results is given in Table 3.72 of Vol. 2. Of the 210 measurements taken, five exceeded 810 pCi/L. Two occurred in the 3000 area next to

Fifth Street (5400 pCi/L and 5100 pCi/L), and the other three occurred at an outfall to WOC just below the confluence with Fifth Creek. Elevated levels of gross beta activity are believed to be related to historic contamination, which is being addressed by the Environmental Restoration Program (ERP) for ORNL.

K-25 Site

NPDES effluent monitoring is specified in the K-25 Site NPDES permit TN0002950. This permit expired in February 1989, and application for a new permit was submitted by the K-25 Site to TDC as required. The K-25 Site has written authorization from TDC to continue to operate under the conditions of the expired permit until a renewed permit is issued. Negotiations between TDC and the K-25 Site regarding the permit removal are in progress, and draft permits have been issued. Issuance of a final permit is expected in 1991. The radionuclide analyses for both ambient surface water and NPDES programs are restricted to the types common to past and current plant operations.

Both NPDES and perimeter ambient water sampling locations under K-25 Site responsibility are shown in Fig. 3.5. Table 3.11 lists sampling locations, sample type, the agency requiring the sample, and the NPDES identification number where applicable.

Sample collection for radiological constituents is performed along with NPDES samples. Each K-25 Site location is listed in Table 3.22 along with the sampling frequency and sampling method. A more complete description of the NPDES program is in Sect. 3.2.2.

The K-25 Site's original mission was uranium enrichment. Until the 1950s, activities were very specific and uranium was the principal radionuclide introduced into the plant area. During the 1950s, reactor return feed material was processed at the plant, and this activity introduced transuranic and fission products into the plant facilities. The radioisotopes specifically encountered were technetium, cesium, neptunium, and plutonium. The uranium enrichment process has now been shut down, and radioactive materials are no longer being introduced into the process. If additional isotopes are introduced to the plant site, monitoring of effluents will be reassessed.

The K-1700 and K-1407-J NPDES point (Fig. 3.5) have the greatest potential for radioactive emissions because of the facilities operating nearby. The K-1203 sewage plant has the second greatest potential for radioactive emissions, followed by the K-1407-E/F Ponds. K-1007-B and K-901-A ponds have the least potential because no process effluents entering these ponds should contain radioactivity. The K-1515-C NPDES point receives backwash from the sanitary water plant. The intake for this facility is on the Clinch River, and the potential for contamination from the K-25 Site does not exist.

With the exception of K-1515-C, all NPDES discharge points are analyzed weekly for uranium. If any weekly values are above 0.02 mg/L, an isotopic analysis is conducted on the monthly composites for K-1700, K-1203, K-1407-J, and K-1407-E/F, and on the quarterly composites for K-1007-B and K-901-A. Isotopic analyses cannot be performed readily on samples with concentrations of <0.02 mg/L. In addition, K-1700, K-1407-J, and K-1407-E/F receive technetium, cesium, neptunium, and plutonium analyses on the monthly composite samples. K-1203 receives technetium analysis on the monthly composites, and K-901-A and K-1007-B receive technetium, cesium, neptunium, and plutonium on the quarterly composite samples. These data are transmitted quarterly to the state with the DMRs.

The data indicate that radiological effluents are well within limits at all effluent locations (see Tables 3.12 through 3.17 in Vol. 2), with the exception of K-1407-J and K-1700. Uranium, determined by wet chemistry analysis, is reduced and presented by isotope in the Vol. 2 tables. Most values are well below the DCG. At K-1407-J, ^{234}U is 34.5% of the DCG, and ^{238}U is 14.5% of the DCG. These values are lower than the 1989 data, as shown in Table 3.2 in Vol. 2. The levels of plutonium are increased at these outfalls. K-1407-J is 56.9% of the DCG, and K-1700 is 37.4% of the DCG.

3.2.2 Nonradiological summary

Y-12 Plant

Over the past few years, significant changes in the interpretation of existing environmental legislation have impacted the environmental management program at the Y-12 Plant. Until 1977, EPA had total responsibility for enforcing the CWA

Table 3.22. K-25 Site NPDES sampling frequency

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-1700 (001)	Grab	Daily		pH
K-1700 (001)	*b*	Daily		Flow
K-1700 (001)	24 h/comp.	2/week		Aluminum
K-1700 (001)	24 h/comp.	4/week		Chemical oxygen demand
K-1700 (001)	24 h/comp.	2/week		Chromium
K-1700 (001)	24 h/comp.	2/week		Dissolved solids
K-1700 (001)	24 h/comp.	2/week		Fluoride
K-1700 (001)	24 h/comp.	2/week		Nitrate
K-1700 (001)	Grab	2/week		Oil and grease
K-1700 (001)	24 h/comp.	4/week		Total suspended solids
K-1700 (001)	Grab	4/week		Temperature
K-1700 (001)	Grab	4/week		Turbidity
K-1700 (001)	24 h/comp.	2/week		Lead
K-1700 (001)	24 h/comp.	2/week		Zinc
K-1700 (001)	24 h/comp.	1/week		Uranium[c]
K-1700 (001)	24 h/comp.	1/week	1/month	Cesium
K-1700 (001)	24 h/comp.	1/week	1/month	Neptunium
K-1700 (001)	24 h/comp.	1/week	1/month	Plutonium
K-1700 (001)	24 h/comp.	1/week	1/month	Technetium
K-1203 (005)	Grab	Daily		pH
K-1203 (005)	Grab	Daily		Chlorine, residual
K-1203 (005)	Grab	Daily		Dissolved oxygen
K-1203 (005)	Grab	Daily		Settleable solids
K-1203 (005)	*b*	Daily		Flow
K-1203 (005)	24 h/comp.	3/week		Ammonia nitrogen
K-1203 (005)	24 h/comp.	3/week		Biochemical oxygen demand
K-1203 (005)	Grab	3/week		Fecal coliform
K-1203 (005)	24 h/comp.	3/week		Total suspended solids
K-1203 (005)	24 h/comp.	1/week		Uranium[c]
K-1203 (005)	24 h/comp.	1/week	1/month	Technetium
K-1007-B (006)	Grab	Daily		pH
K-1007-B (006)	Grab	1/week		Dissolved oxygen
K-1007-B (006)	*b*	Daily		Flow
K-1007-B (006)	24 h/comp.	1/week		Chemical oxygen demand
K-1007-B (006)	24 h/comp.	1/week		Chromium
K-1007-B (006)	24 h/comp.	1/week		Fluoride
K-1007-B (006)	Grab	1/week		Oil and grease
K-1007-B (006)	24 h/comp.	1/week		Total suspended solids
K-1007-B (006)	24 h/comp.	1/week		Uranium[c]
K-1007-B (006)	24 h/comp.	1/week	1/quarter	Cesium
K-1007-B (006)	24 h/comp.	1/week	1/quarter	Plutonium
K-1007-B (006)	24 h/comp.	1/week	1/quarter	Neptunium
K-1007-B (006)	24 h/comp.	1/week	1/quarter	Technetium
K-901-A (007)	Grab	Daily		pH
K-901-A (007)	Grab	Daily		Dissolved oxygen
K-901-A (007)	*b*	Daily		Flow
K-901-A (007)	24 h/comp.	2/week		Chemical oxygen demand
K-901-A (007)	24 h/comp.	1/week		Chromium
K-901-A (007)	24 h/comp.	1/week		Fluoride
K-901-A (007)	Grab	1/week		Oil and grease
K-901-A (007)	24 h/comp.	2/week		Total suspended solids
K-901-A (007)	Grab	2/week		Turbidity

Table 3.22 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-901-A (007)	24 h/comp.	1/week		Uranium[c]
K-901-A (007)	24 h/comp.	1/week	1/quarter	Cesium
K-901-A (007)	24 h/comp.	1/week	1/quarter	Neptunium
K-901-A (007)	24 h/comp.	1/week	1/quarter	Plutonium
K-901-A (007)	24 h/comp.	1/week	1/quarter	Technetium
K-1515-C (009)	Grab	1/week		pH
K-1515-C (009)	*b*	Daily		Flow
K-1515-C (009)	Grab	1/week		Total suspended solids
K-1515-C (009)	Grab	1/week		Aluminum
K-1515-C (009)	Grab	1/week		Sulfate
K-1515-C (009)	Grab	1/week		Chemical oxygen demand
K-1407-J (011)	Continuous	Daily		pH
K-1407-J (011)	Continuous	Daily		Flow
K-1407-J (011)	Grab	Daily		Temperature
K-1407-J (011)	24 h/comp.	2/week		Cadmium
K-1407-J (011)	24 h/comp.	2/week		Chromium
K-1407-J (011)	24 h/comp.	2/week		Copper
K-1407-J (011)	24 h/comp.	2/week		Lead
K-1407-J (011)	24 h/comp.	2/week		Nickel
K-1407-J (011)	24 h/comp.	2/week		Silver
K-1407-J (011)	24 h/comp.	2/week		Zinc
K-1407-J (011)	Grab	1/week		Cyanide
K-1407-J (011)	Grab	1/week		Total toxic organics
K-1407-J (011)	Grab	2/week		Oil and grease
K-1407-J (011)	24 h/comp.	4/week		Total suspended solids
K-1407-J (011)	24 h/comp.	1/week		Polychlorinated biphenyls
K-1407-J (011)	24 h/comp.	4/week		Chemical oxygen demand
K-1407-J (011)	24 h/comp.	4/week		Total dissolved solids
K-1407-J (011)	24 h/comp.	2/week		Total organic carbon
K-1407-J (011)	24 h/comp.	1/week		Ammonia
K-1407-J (011)	24 h/comp.	1/week		Bromide
K-1407-J (011)	24 h/comp.	1/week		Chlorine, total residual
K-1407-J (011)	24 h/comp.	1/week		Chloride
K-1407-J (011)	24 h/comp.	4/week		Fluoride
K-1407-J (011)	24 h/comp.	2/week		Nitrate-Nitrite
K-1407-J (011)	24 h/comp.	1/week		Nitrogen
K-1407-J (011)	24 h/comp.	1/week		Phosphorus
K-1407-J (011)	24 h/comp.	1/week		Sulfate
K-1407-J (011)	24 h/comp.	1/week		Sulfide
K-1407-J (011)	24 h/comp.	1/week		Sulfite
K-1407-J (011)	24 h/comp.	1/week		Surfactants
K-1407-J (011)	24 h/comp.	2/week		Aluminum
K-1407-J (011)	24 h/comp.	1/week		Barium
K-1407-J (011)	24 h/comp.	2/week		Boron
K-1407-J (011)	24 h/comp.	2/week		Cobalt
K-1407-J (011)	24 h/comp.	2/week		Iron
K-1407-J (011)	24 h/comp.	2/week		Magnesium
K-1407-J (011)	24 h/comp.	2/week		Molybdenum
K-1407-J (011)	24 h/comp.	2/week		Manganese
K-1407-J (011)	24 h/comp.	1/week		Tin
K-1407-J (011)	24 h/comp.	2/week		Titanium
K-1407-J (011)	24 h/comp.	2/week		Antimony

Table 3.22 (continued)

Location	Sampling type	Sample frequency	Analysis[a] frequency	Parameter analyzed
K-1407-J (011)	24 h/comp.	1/week		Arsenic
K-1407-J (011)	24 h/comp.	2/week		Beryllium
K-1407-J (011)	24 h/comp.	2/week		Mercury
K-1407-J (011)	24 h/comp.	2/week		Selenium
K-1407-J (011)	24 h/comp.	1/week		Thallium
K-1407-J (011)	24 h/comp.	1/week		Uranium[c]
K-1407-J (011)	Grab	1/week		Phenols
K-1407-J (011)	Grab	5/week		GC/MS[d] fraction volatile compounds
K-1407-J (011)	72 h/comp.	1/month		GC/MS acid compounds
K-1407-J (011)	72 h/comp.	1/month		GC/MS base/neutral compounds
K-1407-J (011)	24 h/comp.	1/week	1/month	Cesium
K-1407-J (011)	24 h/comp.	1/week	1/month	Plutonium
K-1407-J (011)	24 h/comp.	1/week	1/month	Neptunium
K-1407-J (011)	24 h/comp.	1/week	1/month	Technetium
K-1407-E/F (010)	Grab	Continuous		Flow
K-1407-E/F (010)	Grab	1/week		Temperature
K-1407-E/F (010)	24 h/comp.	1/week		Total suspended solids
K-1407-E/F (010)	Grab	1/week		Oil and grease
K-1407-E/F (010)	24 h/comp.	1/week		Chromium
K-1407-E/F (010)	24 h/comp.	1/week		Copper
K-1407-E/F (010)	24 h/comp.	1/week		Iron
K-1407-E/F (010)	24 h/comp.	1/week		Zinc
K-1407-E/F (010)	24 h/comp.	1/week		Arsenic
K-1407-E/F (010)	24 h/comp.	1/week		Cadmium
K-1407-E/F (010)	24 h/comp.	1/week		Lead
K-1407-E/F (010)	24 h/comp.	1/week		Manganese
K-1407-E/F (010)	24 h/comp.	1/week		Nickel
K-1407-E/F (010)	24 h/comp.	1/week		Selenium
K-1407-E/F (010)	24 h/comp.	1/week		Silver
K-1407-E/F (010)	24 h/comp.	1/month		Sulfate
K-1407-E/F (010)	Grab	Continuous		pH
K-1407-E/F (010)	24 h/comp.	1/week		Polychlorinated biphenyls
K-1407-E/F (010)	24 h/comp.	1/week		Uranium[c]
K-1407-E/F (010)	24 h/comp.	1/week		Cesium
K-1407-E/F (010)	24 h/comp.	1/week		Neptunium
K-1407-E/F (010)	24 h/comp.	1/week		Plutonium
K-1407-E/F (010)	24 h/comp.	1/week		Technetium

[a]Analysis frequency–identical to sample frequency unless otherwise noted.
[b]Not applicable.
[c]An isotopic analysis is conducted on uranium if any week is above 0.02 mg/L.
[d]Gas chromatograph/mass spectrometer.

at federal facilities such as the Y-12 Plant. Under the EPA, the Y-12 Plant had one NPDES permit with four Y-12 perimeter outfalls: one at the outlet of New Hope Pond, one west of the main plant site on Bear Creek (at Highway 95), one at the outlet of Rogers Quarry, and one at the outlet of Kerr Hollow Quarry. While operating under the EPA NPDES permit, the Y-12 Plant regularly achieved compliance with the effluent discharge criteria.

In 1977, amendments to the Federal Water Pollution Control Act (FWPCA) allowed the states to establish their own water quality criteria. By law, these criteria took precedence over any EPA-issued NPDES permits. The current NPDES permit issued May 25, 1985, is a reflection of the 1977 amendments to the FWPCA and the Y-12 Federal Facilities Compliance Agreement signed by EPA and DOE on April 17, 1985. This current NPDES permit combines water quality and industrial BAT effluent limitations for the metal finishing and steam electric power generation industries with emphasis on biological and toxicological monitoring. The Y-12 Plant is committed to achieving effluent characteristics that are better than those specified by BAT. The effluent limitations for each treatment facility may be adjusted if the treated effluent results in in-stream toxicity as determined by TCMP or if East Fork Poplar Creek does not display a healthy ecological system as determined by BMAP. The TCMP is described in Sect. 3.2.3.

Another condition of the Y-12 NPDES permit is the development and implementation of a PCB monitoring plan for the Y-12 Plant. This plan specifies sampling locations and frequencies to identify PCB sources. A summary of these data can be found in Table 3.23.

The Y-12 Plant NPDES permit (No. TN0002968) was issued effective May 25, 1985. The Y-12 Plant NPDES-permitted outfalls are identified in Table 3.24. This permit requires sampling and analysis at 14 serially numbered outfalls, approximately 195 categorized outfalls, and approximately 30 miscellaneous discharges. Analytical results for Y-12 NPDES discharge points for 1990 are summarized in Tables 3.18 through 3.36 of Vol. 2.

Discharges from the Y-12 Plant affect water quality and flow in McCoy Branch, East Fork Poplar Creek, and Bear Creek before entering the Clinch River. The Y-12 Plant is committed to providing treatment for a variety of wastewaters discharged to area streams. Discharges allowed under the permit include storm drainage, cooling water, cooling tower blowdown, and process wastewaters, including effluents from pollution-control facilities. Sumps that collect groundwater inflow in building basements are also discharged to the creek.

The existing Y-12 Plant NPDES Permit expired in May 1990. An application for permit renewal was submitted to TDC/EPA in November 1989. This application contains an extensive collection of proposed monitoring points and subsequent categories. This collection consists of 72 Category-I-type outfalls (uncontaminated precipitation runoff and groundwater), 66 Category-II-type outfalls (roof drains, cooling-water discharges, condensate, and other effluents previously monitored), 4 plant site outfalls, 5 treatment facilities, 20 cooling-tower discharges, 1 fly-ash sluice-water discharge, 40 miscellaneous discharges, and 58 miscellaneous outfalls, for a total of 266 outfalls.

A network of storm drains, which discharges into East Fork Poplar Creek, covers the entire area of the Y-12 Plant. This system gathers rainfall from the adjacent hillsides, parking areas, the roof drains, and the flow from the testing of the fire protection system. In the past, interconnecting with the storm drainage system were numerous discharges and laboratory drains within the buildings, building floor drains, and drains from accumulation tanks outside the buildings. Efforts to improve the water quality of streams receiving Y-12 Plant discharges are ongoing and have resulted in eliminating numerous process discharges to East Fork Poplar Creek.

There are 18 major cooling tower systems and 6 small air-conditioning towers currently in operation at the Y-12 Plant. Approximately 1380 million L (359 million gal) per year of water are required as makeup for the 18 major cooling tower systems. About 550 million L (143 million gal) per year are discharged as blowdown into East Fork Poplar Creek, and 830 million L (216 million gal) are lost as evaporation.

In 1989, as seen in Fig. 3.7, there were three major areas of noncompliance, which included Closure and Post-Closure Activities (CAPCA) (i.e., New Hope Pond, Outfall 303, and the Oil Retention

Table 3.23. Surface water analytical results of polychlorinated biphenyls monitoring plan for the Oak Ridge Y-12 Plant, CY 1990

Site Number	Location	Date sampled	PCB concentration (mg/L)
PCB-1	Outfall 301, Kerr Hollow Quarry	1/08/90	<0.0005
		4/04/90	<0.0005
		7/03/90	<0.0005
		10/25/90	<0.0005
PCB-2	Outfall 302, Roger's Quarry	1/08/90	<0.0005
		4/04/90	<0.0005
		7/03/90	<0.0005
		10/25/90	<0.0005
PCB-3	Outfall 303, New Hope Pond	*a*	
PCB-5	New Hope Pond Inlet	*b*	
PCB-6	Upstream of Outfall 135	1/08/90	<0.0005
		4/04/90	<0.0005
		7/03/90	<0.0005
		10/25/90	<0.0005
PCB-7	Outfall 304, Bear Creek	1/08/90	<0.0005
		4/04/90	<0.0005
		7/03/90	<0.0005
		10/25/90	<0.0005

[a] This outlet was closed in April 1989.
[b] This inlet was closed in November 1988.

Table 3.24. Y-12 Plant NPDES-permitted outfalls, 1990

Quarry—outfall 301
Rogers Quarry—outfall 302
Bear Creek—outfall 304
Interim Liquid Storage Facility—outfall 305 ILSF
Category I outfalls—Uncontaminated precipitation runoff and/or groundwater
Category II outfalls—Cooling water, condensate, building area, and foundation drains and/or precipitation runoff contaminated by area sources of pollution
Category III outfalls—Any of the Category I or II outfalls or process wastewaters requiring treatment at one of the on-site Y-12 treatment facilities
Category IV Discharges—Process wastewaters requiring minimal treatment—outfalls 401–420
Steam Plant fly ash sluice water—outfall 623
Central Pollution Control Facility—outfall 501
West End Treatment Facility—outfall 502
Steam Plant Wastewater Treatment Facility—outfall 503
Plating Rinsewater Treatment Facility—outfall 504
Experimental Mobile Wastewater Treatment Facility—outfall 508
Building 9204-3 Sump Pump Oil Separator—outfall 506
Miscellaneous discharges (cooling towers, regeneration wastes, vapor blasters)

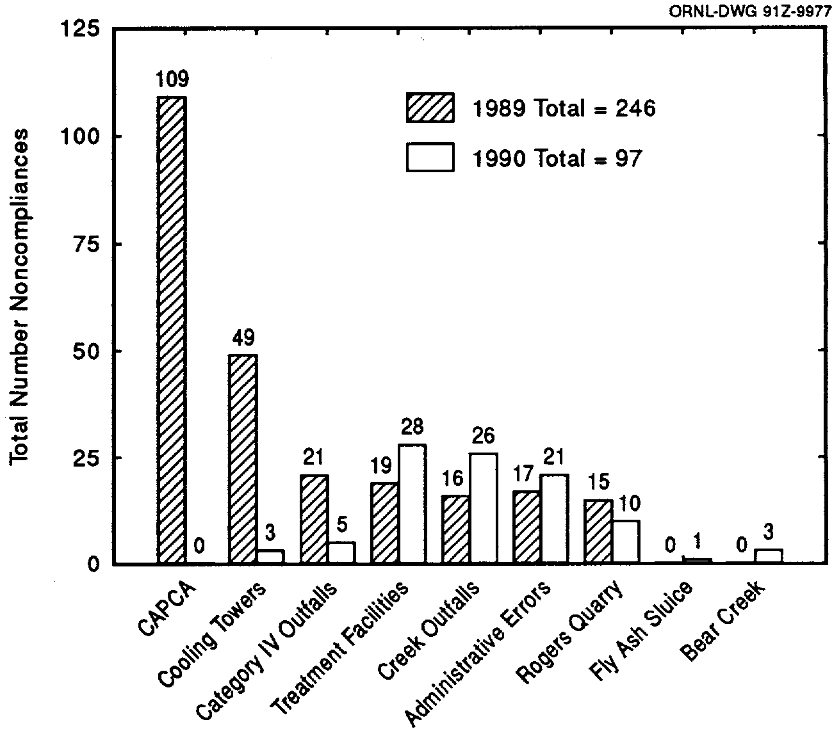

Fig. 3.7. Y-12 Plant NPDES noncompliance status comparison and sources of noncompliances.

Ponds, Outfalls 305 and 306), cooling towers, and Category IV discharges. Noncompliances associated with CAPCA activities accounted for 44% of all 1989 NPDES noncompliances. CAPCA activities at New Hope Pond and at the Oil Retention Ponds were completed in 1989. Hence, Outfalls 303, 305, and 306 have been eliminated.

The Y-12 Plant cooling towers accounted for 20% of all NPDES noncompliances in 1989; in 1990 this percentage was dropped to 3%. This improvement in compliance can be attributed to a change in corrosion inhibitors for pH control, and better operational control for reduced free available chlorine (FAC) excursions. In an effort to eliminate FAC, an ozonation study is under way. This study will determine the feasibility of using ozone in place of a microbicide in order to reduce the amount of chlorine discharged to East Fork Poplar Creek. This study is scheduled to be concluded in 1991.

Category IV discharges at the Y-12 Plant are to either be eliminated or rendered nontoxic by the end of life of the current NPDES permit. Of the original 22 Category IV discharges, 19 have been eliminated from discharge to East Fork Poplar Creek, 1 has been shown to be nontoxic, 1 receives treatment and is undergoing a Toxicity Reduction Evaluation (TRE), and 1 has been reclassified in the NPDES permit application based on chemical analysis and toxicity tests, which have not demonstrated any significant contamination. Plans are currently being formulated to eliminate sink discharges.

In 1990, the three major areas of noncompliance with the plant NPDES permit were treatment facilities, creek outfalls, and administrative errors. Y-12 Plant treatment facilities accounted for 29% of the total number of NPDES noncompliances during 1990. Creek outfalls accounted for 27% of the total number of NPDES noncompliances during 1990. Administrative errors accounted for 22% of the total number of NPDES noncompliances during 1990. Although these three areas accounted for the majority of the NPDES noncompliances during 1990, their relative percent compliance as compared to 1989 has not significantly increased.

Rogers Quarry (Outfall 302) and improvements related to coal ash disposal are discussed in Special Studies Section 9.1.11.

The Y-12 Plant generates a variety of liquid wastes (uranium-contaminated as well as uranium-noncontaminated) from activities associated with metal finishing, plating, uranium recovery, and facility cleaning operations. Conventional liquid waste streams such as storm water runoff, steam plant wastewaters, and coal-pile runoff also exist. Aqueous process waste streams may be divided into two categories: high-nitrate wastewaters and low-nitrate wastewaters. With the exception of the high-nitrate wastewaters, the waste streams are amenable to physical/chemical types of treatment including pH control and solids removal. Wastewater treatment facilities that can accommodate specific waste streams (plating rinsewaters, high-nitrate streams, etc.) have been built in recent years.

Wastewaters at the Y-12 Plant are treated by one of the following methods.

- Nitrate-contaminated wastewaters generated throughout the plant are neutralized, biodenitrified, stored, polished, and discharged at the WETF.
- Wastewaters that are low in nitrates are collected and transported to the CPCF.
- Coal-pile runoff and boiler blowdown are collected and treated at the SPWTF.
- Sanitary wastes are discharged to the City of Oak Ridge wastewater treatment facility under an Industrial User's Permit.
- Wastewaters from the ORNL Biology Complex at the Y-12 Plant are discharged to the sanitary sewer system, where they continue on to the City of Oak Ridge wastewater treatment facility.
- Untreated waste streams such as cooling tower blowdown and noncontact cooling waters are monitored to ensure compliance with the NPDES permit. These waters are discharged to East Fork Poplar Creek.

During 1989, the Y-12 Plant improved to 98% compliance with NPDES standards as compared with 97% compliance in 1988. These trends can be seen in Figs. 3.8 and 3.9.

Progress was also made during 1990 to minimize the release of pollutants to surface waters at the Y-12 Plant through improvement of the BMP guidance program.

Based on requirements established in Y-12 Plant Procedure 70-909, state and federal environmental regulations, and Best Management Practices (BMPs), a committee was established in February 1990 to review dike water discharge practices throughout the plant. The committee reviewed more than 100 dikes in an attempt to evaluate and update the internal program directed at assisting the plant in controlling these discharges to the surface water. As a result of the committee's audits, an interim discharge approval system was instituted that has established required monitoring and limits on parameters that must be met prior to discharge to the storm sewer. Records of all discharges are maintained by the committee, and each operator responsible for a dike discharge is required to maintain records in an area log.

All Category IV discharges with the exception of one facility discharge have been eliminated from discharging to EFPC either by physical reroute or a cessation of process. Action plans to physically remove the one active and the several inactive Category IV sources are currently being implemented. For a more detailed discussion of the treatment of Category IV discharges, refer to Special Studies Section 9.1.8.

Information obtained from the Source/Drain Survey, which is a survey of process sources tied to the storm drain, has been analyzed and distributed to various building contacts for their reference and information. Administrative controls are being placed on any sources that are unpermitted for drainage to the storm system. Action plans to eliminate these inappropriate sources are currently being developed and implemented. For further details on the Source/Drain Survey, refer to Special Studies Section 9.1.6.

Additionally, a chlorine-reduction feasibility study was initiated in 1990 to target a reduction in chlorine loading due to once-through–cooling-water discharges to EFPC and to achieve compliance and improve water quality of EFPC. Installation of reduction equipment is scheduled for FY 1992 and FY 1993. See Special Studies Section 9.1.9 for further description of this study.

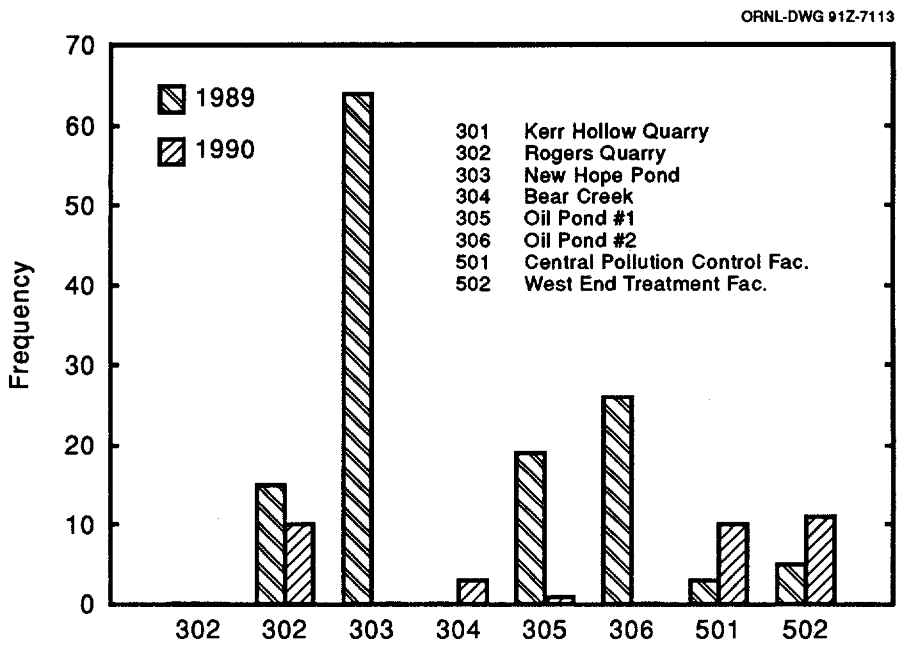

Fig. 3.8. Y-12 Plant excursion trend, 1989–1990.

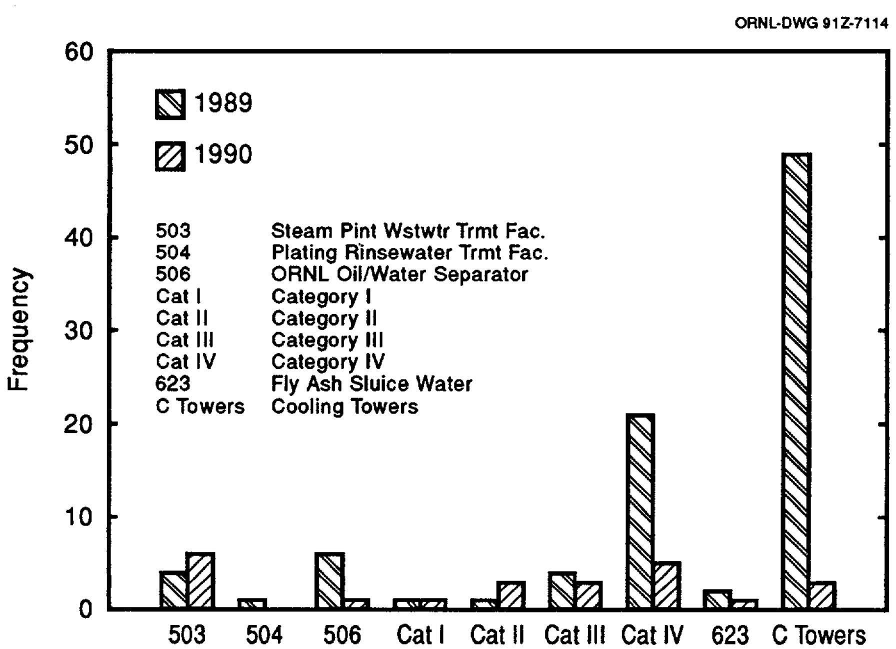

Fig. 3.9. Y-12 Plant excursion trend, 1989–1990.

ORNL-DWG 89M-6365R5

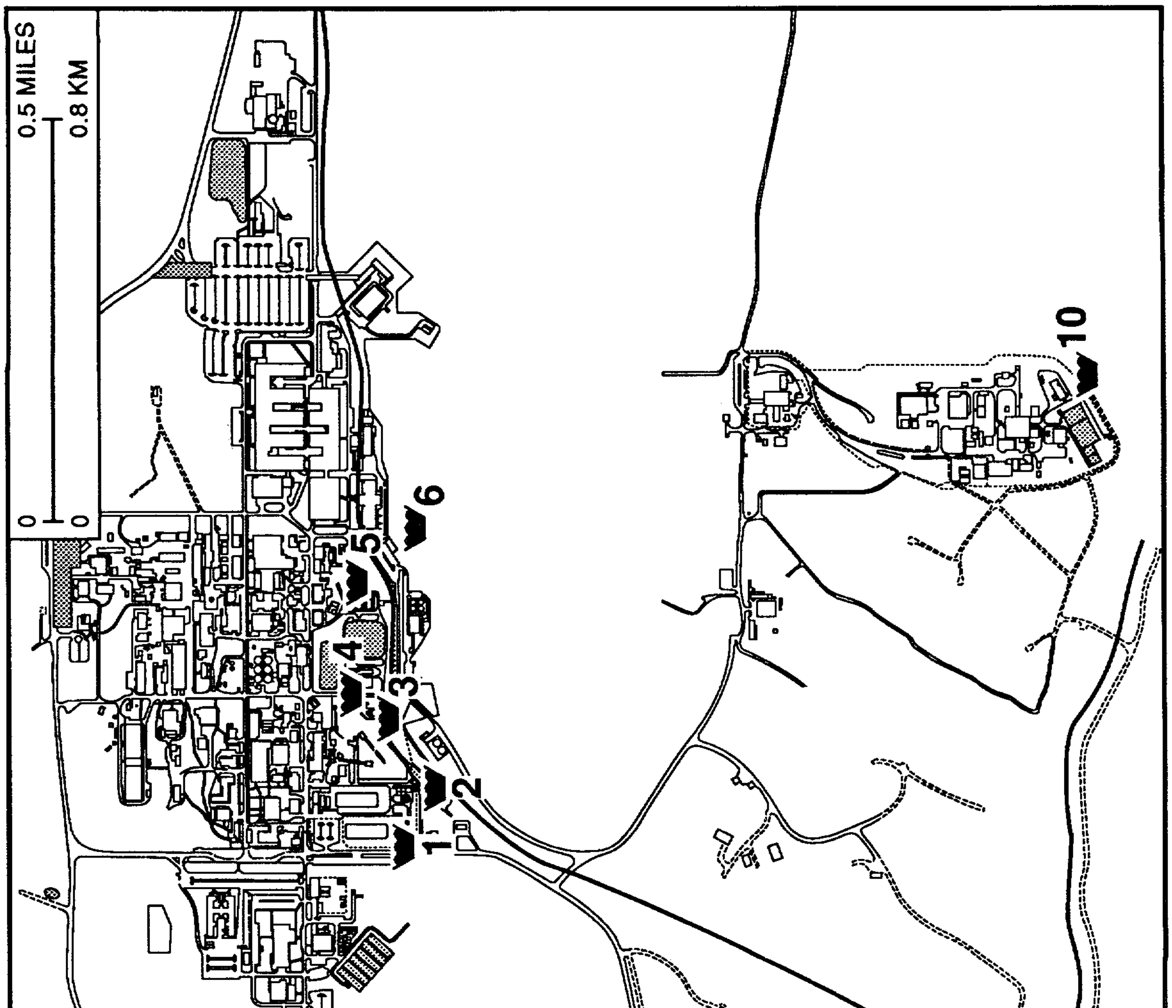

Fig. 3.10. ORNL NPDES and radioactivity sampling locations.

Oak Ridge National Laboratory

The ORNL NPDES permit (TN0002941) became effective on April 1, 1986. The point source and ambient stations are shown in Fig. 3.10. Table 3.37 in Vol. 2 gives the average and maximum flows for the point sources as specified in the permit. It also identifies the receiving stream.

Sampling and analysis frequencies at these locations are varied, as indicated in Tables 3.38 through 3.54 in Vol. 2. Effluent limits have been placed on the Sewage Treatment Plant (STP), the Coal Yard Runoff Treatment Facility (CYRTF), and the Nonradiological Wastewater Treatment Facility; Categories I, II, and III outfalls; and the miscellaneous source discharges. Discharge limits are also placed on pH for most of the outfalls.

Construction of ORNL's new Nonradiological Wastewater Treatment Facility was completed in September 1989. This facility came online April 1, 1990. Consequently, outfalls X03, X04, X06, X06A, X07, X08, X09, X09A, and X11 were eliminated.

A summary of the NPDES compliance at ORNL is given in Table 3.19, which provides a list of outfalls, parameters measured for which there is a permit limit, the discharge limitations, the number of noncompliances, and the percentage in compliance for 1990. The percentage is based on the total number of observations for a particular parameter at a particular outfall.

At the STP (discharge point X01), the compliance rate was greater than 95% for all parameters measured. The 1990 exceedances of total suspended solids and oil and grease parameters were based on one and two excursions of each parameter, respectively. The additional noncompliances were based on monthly-average and mass-load calculations that were influenced by the individual excursions.

For one oil and grease (O&G) noncompliance, no certain cause was found. The other total suspended solids (TSS) and O&G exceedances were attributed to adverse conditions caused by unusually heavy rainfall events in May and December 1990. The chlorine limit exceedance was attributed to a temporary excursion in the chlorine level in the STP effluent. The fecal coliform violation was based on miscommunication of appropriate detection limits, not on a known discharge of noncompliant effluent.

Category I and II outfalls include storm drains and parking lot and roof drains and are not contaminated by any known activity, nor do they discharge through any oil/water separator or other treatment facility or equipment. During rain events, waters from the parking lots and surrounding areas wash into these outfalls, carrying oil, grease, and other residue. This situation frequently results in noncompliances for O&G, as well as TSS, at a number of these outfalls. A study was conducted in 1990 to investigate the feasibility of various alternatives to control the exceedances at Category I and II outfalls. Additional studies are currently under way with regard to new stormwater regulations promulgated by the EPA in November 1990.

The TSS exceedance was attributed to heavy algae growth in the CYRTF discharge basin in June 1990. The O&G exceedance was attributed to an oil seal failure that allowed oil to enter CYRTF effluent in July 1990. This condition was repaired immediately. The exceedances of pH and iron limits were attributed to adverse conditions resulting from an unusually heavy rainfall in December 1990.

In 1989 the Vehicle Cleaning Facility (VC7002) sampling point was revised in an effort to provide more representative samples. Numerous exceedances spurred an ORNL investigation into the situation, which determined that the VC7002 effluent oil separator/grease trap was inadequate. Discharge from the Vehicle Cleaning Facility was halted in the first quarter of 1990, and ORNL is working to install appropriate cleaning equipment.

The pH limit exceedance situation at the ORNL steam plant (SP 2519) continued in 1990. An earlier ORNL investigation indicated that the pH standard was not actually being violated by the discharge at the point of entry to the receiving stream. As allowed by ORNL's NPDES permit, an application was submitted to the TDC requesting that permit limits be adjusted accordingly. In February 1990, ORNL conducted additional checks on this situation, which again indicated no violation of pH or temperature water quality standards. ORNL then submitted correspondence to TDC indicating that SP 2519 monitoring would be discontinued.

A 1988 cooling tower upgrade program resulted in a general decrease in the concentrations of metals discharged in cooling tower blowdown; however, occasional permit limit exceedances still occurred. Additional investigations took place in 1990 to identify measures to further eliminate exceedances, including procedural revisions and installing equipment to automatically regulate temperature and chlorine discharges at some towers.

All data collected for the NPDES permit are also summarized monthly for reporting to DOE-ORO and to the state of Tennessee. These summaries are submitted to DOE in monthly DMRs. Monthly summaries of sampling for the NPDES permit are found in Tables 3.55 through 3.73 of Vol. 2.

ORNL NPDES experienced six exceedances of the EPA Chronic Water Quality Criteria in 1990 (Tables 3.25 and 3.26). Melton Branch (NPDES station number X13) exceeded the criteria for the maximum concentrations of iron (3.9 mg/L) and mercury (0.00010 mg/L). White Oak Creek (NPDES station number X14) exceeded the criteria for the maximum concentrations of copper (0.014 mg/L) and mercury (0.00022 mg/L). White Oak Dam (NPDES station number X15) exceeded the criteria for the maximum concentrations of mercury (0.0060 mg/L and 0.0080 mg/L). The maximum concentration of copper (0.018 mg/L) equaled the EPA Acute Water Quality Criterion. This information is provided to put the data in perspective. Surface water from the facility is not a source of drinking water. Table 3.9 shows the dilution ratios for White Oak Creek by the Clinch River. The maximum value for sulfate at X13 appears to be in error. All records have been reviewed, and the sulfate values for that sample date associated with X02 and X13 appear to have been switched. Information in the tables reflect the data as received.

K-25 Site

The current NPDES permit for the K-25 Site has eight authorized discharge points (Fig. 3.5). Samples are collected at seven of the eight outfalls and at three internal wastewater discharges. The eighth outfall has been shut down because of insufficient loading and is not monitored. All process water discharges from the plant pass through an NPDES monitoring point. However, many storm drains, some with noncontact cooling water discharges, are not currently monitored at an NPDES sampling point. The NPDES permit for the K-25 Site is currently in the process of renewal and is scheduled for final issuance by TDC in 1991. Monitoring of all storm drain outfalls at the facility will be a requirement of the renewal permit. In addition, several projects are being pursued to remove cooling water discharges from the plant storm drain system. Since the K-25 Site has been in standby mode, the major decreases in liquid discharges have been the result of the elimination of blowdown from both the recirculating cooling water (RCW) system and the centrifuge development cooling towers and a decrease in sewage effluent. The discharges are described according to their NPDES outfalls in Table 3.27. Each K-25 Site location is listed in Table 3.22 along with sampling frequency and sample type. All analyses are performed according to EPA-approved procedures.

The K-25 Site operates one sanitary sewage system—an extended aeration treatment plant with a rated capacity of 2.3 million L/d (0.6 Mgd) and a current use of approximately 1.1 million L/d (0.3 Mgd). Treated effluent from the main plant is discharged into Poplar Creek.

Because of their remoteness and low volume of use, outlying facilities such as the power house area, rifle range, and water treatment plant use septic tanks with drain fields. The power house area has a packaged treatment plant with a rated capacity of 76,000 L/d (19,760 gal/d); however, because of insufficient loading, this facility has been shut down and is not monitored. It is included in the NPDES permit as an inactive outfall and can be reactivated if necessary.

Surface runoff within the K-25 Site is drained by Mitchell Branch and Poplar Creek, which flow into the Clinch River. Improvements to the surface runoff system include drainage channeled by swales, where appropriate, rather than by piped drain systems. This technique is used to moderate stream flows by enhancing percolation to groundwater systems and reducing runoff quantity and rate.

Two cooling towers that operate at the K-25 Site, K-822 and K-1101, will be included in the monitoring requirements for the renewed NPDES permit. They require 800,000 L/d (208,000 gal/d) of makeup water; 600,000 L/d (156,000 gal/d) are evaporated to the atmosphere, and 200,000 L/d (52,000 gal/d) are discharged as blowdown. Three additional cooling towers are in operation, but because they discharge <10,000 gal/d, are specifically used for space cooling, do not utilize water conditioning chemicals containing chromium, and do not violate applicable water quality standards,

Table 3.25. 1990 ORNL NPDES Permit Number TN 0002941

Discharge point X15—White Oak Dam

Parameter	Number of samples	Concentration (mg/L)			
		Max[a]	Min[a]	Av[a]	Standard error
Aluminum, total	14	1.4	<0.050	0.52	0.088
Ammonia, as N	12	0.15	0.020	0.075	0.014
Arsenic, total	15	<0.050	0.0020	0.036	0.0053
Biochemical oxygen demand	12	<5.0	<5.0	<5.0	0
Cadmium, total	15	<0.0050	<0.0020	<0.0026	0.00032
Chlorine, total residual	52	<0.010	<0.010	<0.010	0
Chloroform	12	<0.0050	J0.0010	J0.0040	0.00052
Chromium, total	14	0.020	<0.0040	0.013	0.0012
Conductivity, mS/cm	12	1.9	0.26	1.4	0.16
Copper, total	14	0.018	<0.0050	<0.0075	0.00094
Dissolved solids, total	12	260	160	210	8.8
Flow, Mgd	250	100	3.2	11	0.79
Fluoride, total	12	1.0	<1.0	<1.0	0
Iron, total	14	1.2	<0.050	0.59	0.082
Lead, total	15	<0.050	<0.0040	<0.014	0.0049
Manganese, total	19	0.16	<0.0010	<0.088	0.0092
Mercury, total	14	0.00008	<0.00005	<0.000053	0.0000022
Nickel, total	14	<0.0090	<0.0040	<0.0054	0.00053
Nitrate, as N	12	5.0	<5.0	<5.0	0
Oil and grease	52	180	<2.0	<10	3.6
Organic carbon, total	12	6.8	2.0	3.3	0.42
Oxygen, dissolved	52	21	5.1	9.0	0.40
PCBs, total	12	B0.0069	<0.00050	<0.0019	0.00050
pH, standard units	12	8.8	7.2	*b*	*b*
Phosphorus, total	15	1.0	0.20	0.40	0.052
Silver, total	15	<0.0050	<0.0050	<0.0050	0
Sulfate, as SO_4	12	67	21	40	3.9
TSS	12	27	<5.0	13	2.3
Temperature, °C	64	29	7.2	18	0.82
Trichloroethene	12	<0.0050	<0.0050	<0.0050	0
Turbidity, JTU	12	320	9.0	87	23
Zinc, total	14	0.074	0.0079	0.021	0.0045
		Concentration (pCi/L)			
^{60}Co	52	62	−11	8.2	1.4
^{137}Cs	52	380	7.8	47	7.5
Gross alpha	52	30	−28	6.1	1.2
Gross beta	52	780	27	420	20
^{191}Os	1	89	89	89	*b*
^{238}Pu	1	−0.081	−0.081	−0.081	*b*
^{239}Pu	1	−0.081	−0.081	−0.081	*b*
Total Sr	12	300	140	200	13
^{3}H	12	300,000	97,000	190,000	19,000
^{234}U	1	5.1	5.1	5.1	*b*
^{235}U	1	1.7	1.7	1.7	*b*
^{238}U	1	0.92	0.92	0.92	*b*

[a] < = undetected; J = below detection limit, but estimated; B = found in the blank.
[b] Not applicable.

Table 3.26. NPDES Permit Number TN 0002941

Discharge point X13—Melton Branch

Parameter	Number of samples	Concentration (mg/L)			
		Max[a]	Min[a]	Av[a]	Standard error
Aluminum, total	14	5.3	<0.050	<1.0	0.46
Ammonia, as N	12	0.060	0.020	0.040	0.0036
Arsenic, total	14	0.066	<0.050	<0.051	0.0011
Biochemical oxygen demand	12	<5.0	<5.0	<5.0	0
Cadmium, total	15	<0.0050	<0.0020	<0.0026	0.00032
Chlorine, total residual	52	<0.010	<0.010	<0.010	0
Chloroform	12	<0.0050	J0.0010	J0.0045	0.00036
Chromium, total	14	0.016	<0.0040	<0.0080	0.00093
Conductivity, mS/cm	12	2.4	0.26	1.6	0.20
Copper, total	14	0.015	<0.0050	<0.0081	0.00081
Dissolved solids, total	12	530	130	280	37
Flow, Mgd	250	48	0.35	2.4	0.32
Fluoride, total	12	3.0	<1.0	<1.3	0.17
Iron, total	14	3.9	0.14	0.87	0.35
Lead, total	15	<0.050	<0.0040	<0.013	0.0049
Manganese, total	14	0.38	0.050	0.14	0.026
Mercury, total	14	0.00010	<0.00005	<0.000054	0.0000036
Nickel, total	14	0.014	<0.0040	<0.0058	0.00078
Nitrate, as N	12	<5.0	<5.0	<5.0	0
Oil and grease	52	250	<2.0	<8.6	4.7
Organic carbon, total	12	5.6	2.0	3.1	0.29
Oxygen, dissolved	52	19	5.2	9.3	0.34
PCBs, total	12	B0.0046	<0.00050	<0.0017	0.00033
pH, standard units	12	8.8	7.2	*b*	*b*
Phosphorus, total	15	1.7	<0.10	<0.61	0.11
Recoverable phenolics, total	12	<0.0010	<0.0010	<0.0010	0
Silver, total	15	<0.0050	<0.0050	<0.0050	0
Sulfate, as SO_4	12	1900	13	220	150
TSS	12	120	<5.0	<21	11
Temperature, °C	64	26	5.7	16	0.78
Trichloroethene	12	<0.0050	J0.0020	<0.0048	0.00025
Turbidity, JTU	12	110	5.0	69	11
Zinc, total	14	0.059	<0.0050	0.020	0.0043
		Concentration (pCi/L)			
^{60}Co	12	51	-16	18	7.1
^{137}Cs	12	49	-24	10	7.6
Total Sr	12	920	250	460	53
Tritium	12	1,600,000	300,000	810,000	92,000

[a]< = undetected; J = below detection limit, but estimated; B = found in the blank.
[b]Not applicable.

Table 3.27. K-25 Site NPDES permit discharges

Serial discharges	Effluent discharges	Average flow (gal × 10^6/d)	Receiving stream
K-1700 (001)	K-1407-E/F effluent surface runoff once-through cooling	0.81	Poplar Creek
K-1407-J (011)	Metals cleaning facility Uranium recovery Chemical Process Development Facility TSCA Incinerator	0.006	Poplar Creek
K-1407-E/F (010)	Steam plant and coal yard effluents Surface runoff	0.105	Mitchell Branch
K-901-A (007)	Lime-softening sludges from fire water makeup treatment Surface runoff	1.87	Clinch River
K-1203 (005)	Sanitary wastewaters Organic industrial wastewaters	0.47	Poplar Creek
K-1007-B (006)	Potable water from once-through cooling systems Fire water from once-through systems Surface runoff	1.76	Poplar Creek
K-1515-C (009)	Water from sludge and back-wash systems associated with the potable water plant Surface runoff	0.48	Clinch River

they will be exempt from monitoring requirements in the renewed permit.

Only the K-1407-B NPDES discharge location has changed as a direct result of the closing of the K-1407-B surface impoundment as mandated by the reauthorized RCRA. The K-1407-B pond had been used primarily for flow equalization and settling of solids from neutralization activities.

As required by the 1986 NPDES permit modification, the K-1407-B pond was removed from service in November 1988, and the permitted NPDES point was split to accommodate the two effluent streams from the Central Neutralization Facility (CNF). One stream contains small quantities of uranium contamination from the uranium recovery facility, metals from the metal cleaning facility, and effluents from the TSCA Incinerator; the other contains only coal pile and steam plant effluents. These wastestreams receive treatment at the CNF before discharge. In November 1988, the coal pile effluents and steam plants began discharging through K-1407-E and K-1407-F ponds. These ponds are considered as one NPDES discharge location in the current permit because they contain similar treated effluents and discharge alternately (Fig. 3.5). In September 1989, the K-1407-J discharge was redirected from Mitchell Branch to Poplar Creek to eliminate any impact to the Mitchell Branch aquatic community.

Table 3.20 lists the TN0002950 NPDES permit limits, number of noncompliances, and percentage of compliance for all K-25 Site locations. Overall, a

99.9% compliance rate was maintained with the NPDES permit during 1990. Individual parameters are listed by annual values for all the K-25 Site NPDES locations in Tables 3.74 through 3.82 in Vol. 2. The variety of parameters measured at K-1407-J is required to characterize this effluent for new treatment facilities' discharges. Most organics are below detection limits.

The excellent operating record at the K-1203 sewage treatment plant was reflected by only one noncompliance with numerical permit limitations during 1990. The noncompliance occurred when the residual chlorine concentration in the effluent from the facility exceeded the maximum permitted level. Early in the year when the plant was overloaded because of heavy rains, three unpermitted discharges occurred when untreated sewage combined with rainwater was discharged to Poplar Creek. As a result of the incidents, operating procedures were revised, and no additional incidents occurred in 1990.

It is believed that noncompliances for aluminum at K-1700 and chemical oxygen demand (COD) and dissolved oxygen at K-1007-B, as well as noncompliances for suspended solids at K-901-A, are caused by natural phenomena. As evidenced by the draft of the NPDES permit, which is currently in the process of renewal, these outfalls will be reclassified as ambient monitoring stations with no numerical limitations.

The remaining noncompliances were process-related conditions and were addressed individually. When noncompliances of this type occurred, procedures and field activities were reviewed, and changes were made to help eliminate future occurrences.

Four noncompliances for iron occurred at K-1407-E and F ponds. Efforts are under way to expedite removal of the coal pile, the runoff from which comprises most of the treated effluent discharged to the pond. When the coal pile is removed, discharge from the ponds will cease and closure of the ponds will be initiated.

Five unpermitted discharges to storm drains occurred because of spills or pipeline breaks. Each of the incidents were reported under the Occurrence Reporting System (ORS). Corrective actions to prevent reoccurrence were documented and tracked under the ORS.

3.2.3 Toxicity control and monitoring program

In accordance with the NPDES permits issued to the Y-12 Plant on May 24, 1985; ORNL on April 1, 1986; and the permit modification issued to the K-25 Site on September 11, 1986, each plant was required to develop and implement a TCMP. Under the TCMP, toxicity tests with freshwater animals are conducted to determine a wastewater's no-observed-effect concentration (NOEC). Two EPA-approved toxicity tests are used to estimate a wastewater's NOEC: (1) the fathead minnow (*Pimephales promelas*) larval survival and growth test and (2) the *Ceriodaphnia* survival and reproduction test. These two tests, which are static renewal tests (i.e., the test solutions are replaced daily for each species), are described in detail by Horning and Weber (1985). A wastewater's NOEC is computed by comparing the responses of the animals exposed to a contaminant-free water (control water) with those of animals exposed to various concentrations of the wastewater (dilutions are made with the control water). The NOEC is the concentration of wastewater (expressed as a percentage of full strength) that does not adversely affect either fathead minnow larvae survival and growth or *Ceriodaphnia* survival and reproduction. Therefore, the higher the NOEC, the better the quality of the wastewater. The wastewater's NOEC is then compared with its anticipated concentration in the receiving stream [the instream waste concentration (IWC)] to predict whether or not the wastewater will adversely affect the aquatic biota.

Y-12 Plant

Description. In accordance with Part III of the NPDES permit issued to the Y-12 Plant, the plant is required to develop and implement a TCMP. Under the TCMP, various permitted discharges are evaluated for toxicity.

Results. Results of the toxicity tests of wastewaters from four treatment facilities (CPCF, Oil Water Separator, PRTF, and WETF), two cooling towers, and one Category IV discharge (Catch Basin) are given in Table 3.28. For each wastewater, the table shows the month the test was conducted, the NOEC for fathead minnows and *Ceriodaphnia*, and the IWC. Average water quality measurements obtained during each toxicity test are shown in Table 3.29. A program summary is shown in Table 3.30.

Wastewaters from the treatment facilities were each tested once during the year. Wastewater from the CPCF, Oil Water Separator, and PRTF was not toxic (NOEC = 100%) to fathead minnows or *Ceriodaphnia*. The WETF wastewater had NOECs for fathead minnows and *Ceriodaphnia* of 10% and 3%, respectively. The IWC for this wastewater is estimated to be 0.90%; it is therefore unlikely that the wastewater would adversely affect the aquatic biota of EFPC.

Wastewater from cooling towers 9409-13 and 9409-22 was tested once during the year. The wastewater was not toxic to either fathead minnows or *Ceriodaphnia* (NOEC = 100%).

Within the context of the TCMP, the only Category IV discharge evaluated during the year was from the Catch Basin. Wastewater from this facility was tested once during the year. The NOECs for the fathead minnows and *Ceriodaphnia* were 50% and 25%, respectively. The IWC for this wastewater was 0.49%; thus, it is unlikely that the wastewater would adversely affect the aquatic biota of EFPC.

Wastewaters from the photographic rinsewater facilities include rinsewater only; fixer and developer solutions are collected separately. These rinsewaters were tested three times during the year as part of a study to evaluate possible forms of pretreatment. No toxicity tests were conducted on untreated photographic rinsewaters in 1989 because the processes did not change from 1988, and elimination of this discharge to Upper East Fork Poplar Creek (UEFPC) is in progress.

Oak Ridge National Laboratory

Description. In accordance with Part V of the NPDES permit issued to ORNL, the laboratory was

Table 3.28. 1990 toxicity test results of Y-12 Plant wastewaters

Discharge facility	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)	In-stream waste concentration[b] (%)
Central Pollution Control Facility (Outfall 501)[c]	Jul	100	100	0.95
Oil Water Separator (Outfall 506)	Aug	100	100	0.004
Plating Rinsewater Treatment Facility (Outfall 504)	Sept	100	100	0.81
West End Treatment Facility (Outfall 502)	Oct	10	3	0.90
Cooling tower 9409-13	Jan	100	100	0.80
Cooling tower 9409-22	Aug	100	100	0.47
Catch Basin (Outfall 408)	Aug	50	25	0.49

[a]No-observed-effect concentration.
[b]Based on an average flow of 2.65 Mgd discharged at EFPC Station 8.
[c]Combination of CPCF and PRTF (Outfall 501/504).

Table 3.29. 1990 average water quality parameters measured during toxicity tests of Y-12 Plant wastewaters

Values are averages of full-strength wastewater for each test (N = 7)

ORNL outfall	Test date	pH (standard units)	Conductivity (μS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
Central Pollution Control Facility (Outfall 501)	Jul	8.0	1,619	75	735
Oil Water Separator (Outfall 506)	Aug	7.8	275	106	140
Plating Rinsewater Treatment Facility (Outfall 504)[a]	Sept	7.0	393	120	124
West End Treatment Facility (Outfall 502)[a]	Oct	8.4	38,400	126	274
Cooling tower 9409-13	Jan	8.1	674	71	304
Cooling tower 9409-22	Aug	8.4	935	127	469
Catch Basin (Outfall 408)	Aug	7.9	118	35	62

[a]Values are for one grab sample.

required to develop and implement a TCMP. Under the TCMP, wastewater from the STP, CYRTF, and NRWTP was evaluated for toxicity. In addition, two ambient, in-stream sites were evaluated; one site is located on Melton Branch (permit point X13) and the other on WOC (permit point X14; see Fig. 3.4).

Results. The results of the toxicity tests of wastewaters from three treatment facilities (CYRTF, STP, and NRWTP) and two ambient stream sites are given in Table 3.31. This table provides, for each wastewater and ambient water, the month the test was conducted and the wastewater's NOEC for fathead minnows and *Ceriodaphnia.* Average water quality measurements obtained during each toxicity test are shown in Table 3.32.

During 1990, the CYRTF was tested five times, the STP was tested twice, and the NRWTP was tested seven times. The CYRTF wastewater's NOEC for fathead minnows and *Ceriodaphnia* ranged from 6% to 12%; the wastewater's IWC ranged from 0.03% to 3.7% (based on critical low flow rate of WOC). The IWC never exceeded the NOEC for the periods tested. Wastewater from the NRWTP was not toxic to either species at full strength.

The two ambient waters were not toxic to fathead minnows or *Ceriodaphnia.* The Melton Branch site (X13) was tested 11 times, and the White Oak Creek site (X14) was tested 10 times. A complete summary of survival and reproduction of *Ceriodaphnia* and of survival and growth of fathead minnows in the ambient waters of WOC and its tributaries will be published in the *Fifth Annual Report on the ORNL Biological Monitoring and Abatement Program* (Loar 1990).

K-25 Site

Description. In accordance with Part IV of the 1986 NPDES permit modification issued to the K-25

Table 3.30. Y-12 Plant toxicity control monitoring program summary information for 1990[a]

Site/Building	Test date	Species	NOEC (%)	IWC[b] (%)	Flow (GPD)
9818 Nitric Acid Still (Outfall 403),	July 12–19	*Ceriodaphnia*	6	1.5	40,000
9818 Nitric Acid Still (Outfall 403)	July 12–19	FHM	25	1.5	40,000
Central Pollution Control Facility (CPCF) (Combination of CPCF and Plating Rinsewater Treatment Facility (PRTF)—Outfall 501/504)	July 19–26	*c*	100	0.95	25,000
Cooling Tower 9409-22	August 9–16	*c*	100	0.47	12,500
Oil Water Separator (Outfall 506)	August 9–16	*c*	100	0.004	106
9202 Catch Basin (Outfall 408)	August 16–23	*c*	25	0.49	13,000
PRTF (Outfall 504)	September 13–20	*c*	100	0.81	21,500
West End Treatment Facility (Outfall 502)	October 11–18	FHM	10	0.90	24,000
West End Treatment Facility (Outfall 502)	October 11–18	*Ceriodaphnia*	3	0.90	24,000
Evaporator Condensate (Outfall 402)	June 14–21	FHM	12	*d*	*e*
Evaporator Condensate (Outfall 402)	June 18–25	*Ceriodaphnia*	3	*d*	*e*
Evaporator Condensate (Outfall 402)	November 1–8	*Ceriodaphnia*	3	*d*	*e*
Evaporator Condensate (Outfall 402)	November 18–18	FHM	6	*d*	*e*

[a]This table is a summary of the effluents and their corresponding no-observed-effect concentration (NOEC). The tests performed were 7-day toxicity tests using *Ceriodaphnia* and fathead minnows (FHM). Where only one NOEC value is given, it is based on both species.

[b]Instream Waste Concentration (IWC) based on 2.64 mgpd at East Fork Poplar Creek, Station 8.

[c]Based on both species.

[d]NOEC is greater than the IWC.

[e]Some information, including flow rate for this effluent, in considered classified and available only to those with a "Q" security clearance.

Table 3.31. 1990 toxicity test results of ORNL wastewaters and ambient waters

Outfall	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)	In-stream waste concentration[b] (%)
Coal Yard Runoff Treatment Facility (X02)	Jan.	25	12	0.03
	March	100	6	0.14
	May	25	12	1.77
	July	100	6	3.7
	Oct.	100	12	2.2
Sewage Treatment Plant (X01)	Feb.	100	50	2.5
	Aug.	100	25	16.8
Nonradiological Wastewater Treatment Facility (X12)	Feb.	100	100	
	April	100	100	
	June	100	100	
	July	100	100	
	Aug.	100	100	
	Oct.	100	100	
	Dec.	100	100	
Melton Branch (X13)	Feb.	100	*d*	
	March	100[c]	100	
	April	*d*	100	
	May	100	100	
	June	100	100	
	July	100	100	
	Aug.	100	100	
	Sept.	100	100	
	Oct.	100[c]	100	
	Nov.	100[c]	100	
	Dec.	100[c]	*d*	
White Oak Creek (X14)	Feb.	100	*d*	
	March	100[c]	100	
	April	*d*	100	
	May	100	100	
	June	100	100	
	July	100	100	
	Aug.	100	100	
	Sept.	100	100	
	Oct.	100[c]	100	
	Nov.	100[c]	100	

[a]No-observed-effect concentration expressed as percent dilution of effluent.
[b]Ratio of effluent flow to critical low flow of White Oak Creek.
[c]Based on growth.
[d]Not tested.

Table 3.32. 1990 average water quality parameters measured during toxicity tests of ORNL wastewaters and ambient waters

Values are averages of full-strength wastewater for each test (N = 7)

Outfall	Test date	pH (standard units)	Conductivity (µS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
Coal Yard Runoff Treatment Facility (X02)	Jan.	7.1	1420	13	708
	March	7.2	1749	2214	985
	May	7.4	2966	23	1697
	July	7.5	2843	29	2123
	Oct.	7.4	3024	22	2177
Sewage Treatment Plant (X01)	Feb.	7.9	432	95	168
	Aug.	7.9	402	96.8	159
Nonradiological Wastewater Treatment Facility (X12)	Feb.	7.8	161	63	80
	April	8.0	479	81	93
	June	8.0	430	86	85
	July	7.9	634	82	76
	Aug.	8.0	502	88	88
	Oct.	8.0	769	92	175
	Dec.	7.8	716	58	158
Melton Branch (X13)	Feb.	7.9	227	100	120
	March	8.2	303	140	129
	April	8.1	292	129	156
	May	8.0	482	115	232
	June	8.1	332	113	158
	July	8.2	331	123	166
	Aug.	8.0	554	106	273
	Sept.	8.1	519	113	246
	Oct.	8.0	586	115	292
	Nov.	8.0	455	106	221
White Oak Creek (X14)	Feb.	8.0	266	94	131
	March	8.2	328	117	153
	April	8.1	324	118	160
	May	8.1	332	120	148
	June	8.1	334	114	152
	July	8.2	367	123	166
	Aug.	8.1	344	120	159
	Sept.	8.1	385	124	168
	Oct.	8.1	375	132	170
	Nov.	8.1	347	120	161

Table 3.33. 1990 toxicity test results of the K-25 Site wastewater

K-25 Site outfall	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)
K-1407-E/F	Feb.	100	25
	April	100	6
	June	100	6
	Aug.	100	100
	Oct.	100	6
	Dec.	100	50
K-1407-J	Feb.	100	1
	April	50	100
	June	100	100
	Aug.	100	100
	Oct.	100	100
	Dec.	100	100

[a]No-observed-effect concentration.

Site, the plant was required to develop and implement a TCMP. Under the TCMP, wastewater from the K-1407-E and K-1407-F ponds and K-1407-J basins were evaluated for toxicity on a monthly basis.

Results. The results of the toxicity tests of wastewaters from K-1407-E/F and K-1407-J are given in Table 3.33. This table provides, for each wastewater, the month the test was conducted and the wastewater's NOEC for fathead minnows and *Ceriodaphnia*. Average water quality measurements obtained during each toxicity test are shown in Table 3.34.

Wastewater from the K-1407-E/F pond was tested six times during the year. The NOEC for the fathead minnows was always 100%. The NOEC for the *Ceriodaphnia* ranged from 6% to 100%. Because the IWC of this wastewater may be 100% during dry periods, the results of the toxicity tests show that the wastewater may adversely affect the aquatic biota in Mitchell Branch.

Wastewater from the K-1407-J basin was tested six times during the year. The NOEC for the fathead minnows and *Ceriodaphnia* was less than 100% once during the year. Beginning in September 1989, this wastewater was discharged to Poplar Creek where it has an IWC of approximately 1%. Therefore, it is unlikely that this wastewater will adversely affect the aquatic biota in Poplar Creek.

3.2.4 Mercury assessment of ORNL streams

The mercury monitoring plan was designed to identify, locate, and minimize all sources of mercury contamination into ORNL waters. The 1988 and 1989 monitoring data provided a basis to recommend to DOE and TDC the elimination of nonstrategic sampling locations. No action has been taken on that recommendation to date. The 1990 data confirm the need to implement the request.

Water and sediments were sampled semiannually during the first and fourth quarter of 1990. Three replications were collected at each sample site. During the first quarter, 82 stations or locations were sampled for water for a total of 246 samples (Figs. 3.11 and 3.12). This is in comparison with 81 stations and 243 samples during the fourth quarter. Of the 82 stations sampled during the first quarter, 9 (11%) had detectable mercury. The highest among these was near Outfall 367 with a concentration of 1.29 ± 0.05 μg/L (spring quarter). The analytical detection limit was 0.05 μg/L and, at the background location (headwaters of White Oak Creek), mercury concentration was 0.04 ± 0.003 μg/L. Outfall 367 discharges into Fifth Creek east of Building 3036, the Isotope Area Storage and Service Building. During the spring quarter of 1989, this station reported a concentration of 3.03 ± 0.34 μg/L. During the fourth

Table 3.34. 1990 average water quality parameters measured during toxicity tests of the K-25 Site wastewaters

Values are averages of full-strength wastewater for each test (N = 7)

K-25 Site outfall	Test date	pH (standard units)	Conductivity (µs/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
K-1407-E/F	Feb.	8.3	2210	76	434
	April	8.4	2265	59	741
	June	8.4	3695	37	814
	Aug.	7.8	2507	41	590
	Oct.	7.9	2811	46	741
	Dec.	8.1	849	62	311
K-1407-J	Feb.	7.8	1285	94	418
	April	8.1	676	177	262
	June	8.7	1926	461	197
	Aug.	8.5	952	151	244
	Oct.	8.3	1441	113	280
	Dec.	8.1	800	54	221

quarter of 1990, mercury was not detectable at this location.

Thirteen stations were sampled for sediments during the spring quarter in contrast to 14 stations during the fall quarter. The 1989 sediment analyses utilized a rigorous digestion procedure using perchloric acid. Laboratory procedures in 1990 (first quarter) were the same, with the perchloric step eliminated during the fourth quarter. Figure 3.13 shows the locations of elevated mercury concentrations during the first quarter. The maximum concentration (spring quarter) detected was below Outfall 261 with a mean of 1256 ± 419 µg/g. White Oak Creek Headwaters (background) sediments contained 0.04 ± 0.003 µg/g. Outfall 261 enters Fifth Creek from east of Building 3500. The second highest contaminated area was below Outfall 362 with a first quarter concentration of 33.03 ± 12.74µg/g. The fourth-quarter concentration was reported as <0.05 µg/g.

During 1989, a catchment box below Outfall 362 contained 156 µg/g during the first quarter and 6 µg/g during the fourth quarter. The box was removed by a storm event early in 1990, with no subsequent data available.

3.2.5 Polychlorinated biphenyls in the aquatic environment

A PCB monitoring plan was developed and implemented in compliance with the Clean Water Act and the ORNL NPDES permit to assess potential movement in on-site drainage systems and the potential for discharge to off-site receiving waters. To establish a base-line for environmental concentration data, duplicate water samples were collected quarterly and sediments semiannually from locations depicted in Fig. 3.14 and Fig. 3.15. Summary data by sampling station are presented in Table 3.83 in Vol. 2. The concentrations of PCBs in water (by Aroclors) in 1990 were below the analytical detection limit at all sampling locations. However, the blanks associated with the samples were contaminated, and the Aroclors identified were suspect. Some concentrations were reported because the presence of several compounds were detected qualitatively. From 672 water samples representing four sampling quarters, PCBs were detected in only 1.0% of the samples. Water chemistry from Station 8 (Melton Hill Lake south of the 7600 area) indicated Aroclor-1016 present in one sample at 1 µg/L. Data for Station 9 (Melton Hill Lake south of Ramsey

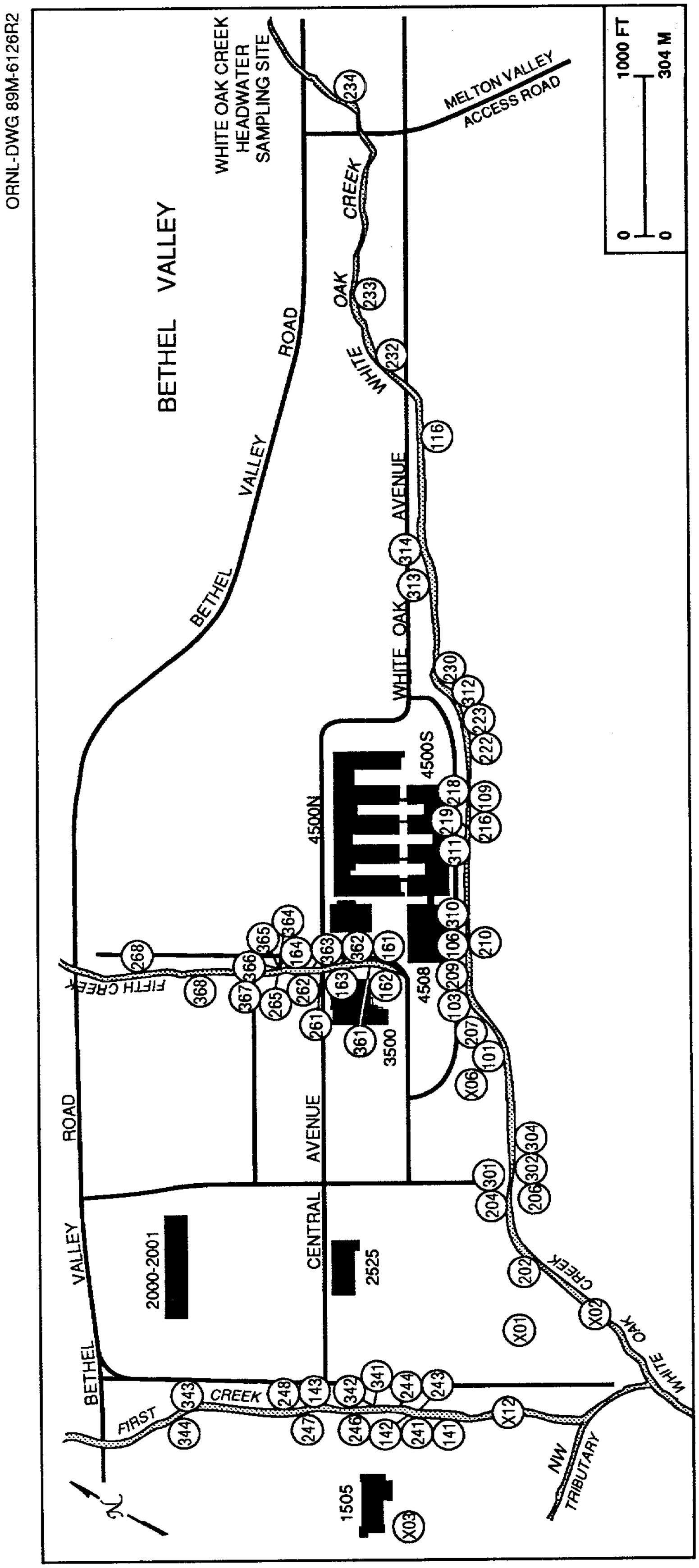

Fig. 3.11. Map of water sampling locations for mercury in the ORNL area. The circled numbers show the sample locations.

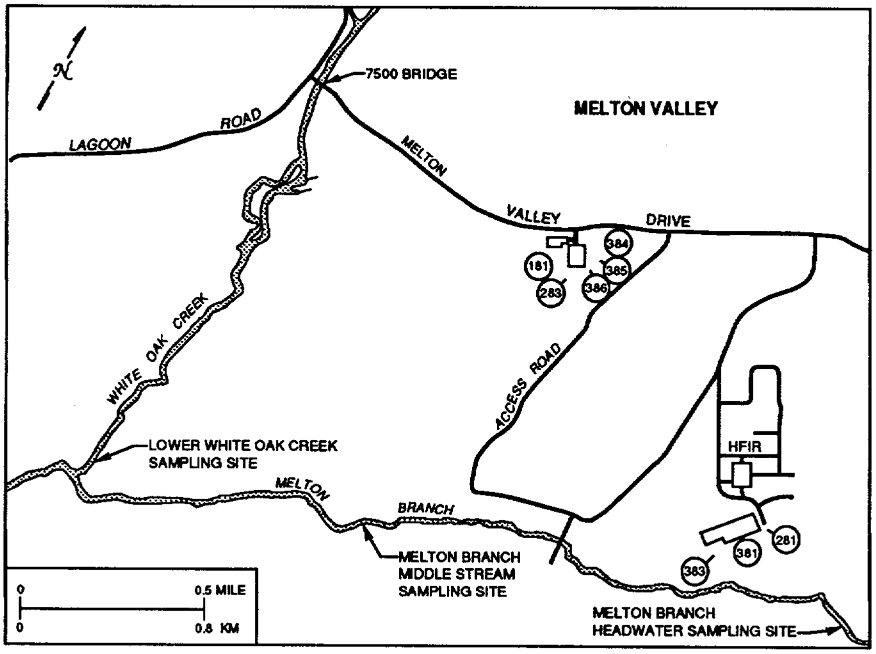

Fig. 3.12. Map of water sampling stations for mercury in the ORNL Melton Valley complex. The circled numbers show the sample locations.

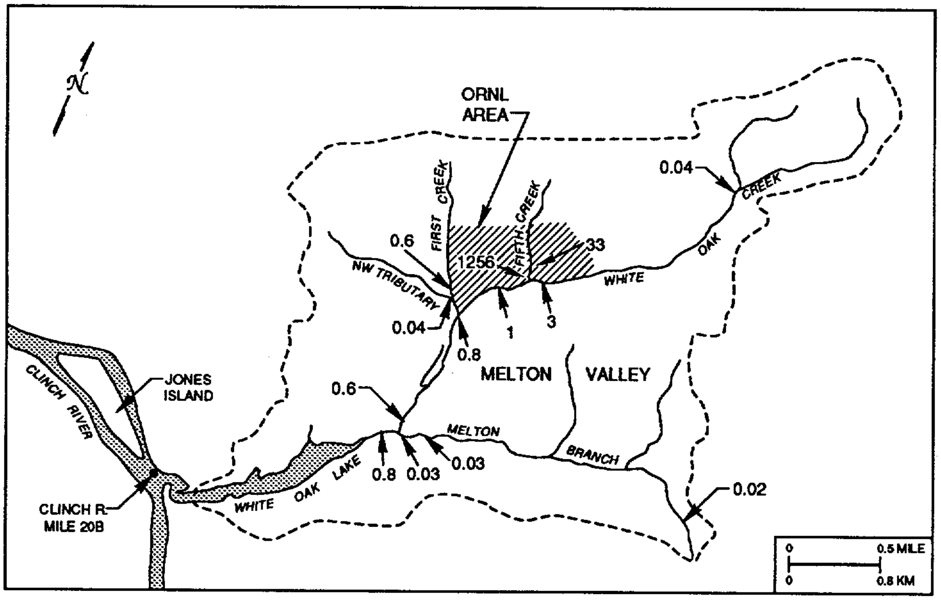

Fig. 3.13. Map of locations in ORNL streams with excess mercury in sediments. Data represent first quarter 1990. Values are average (n = 3) concentrations expressed in µg\kg.

ORNL-DWG 90M-5777R

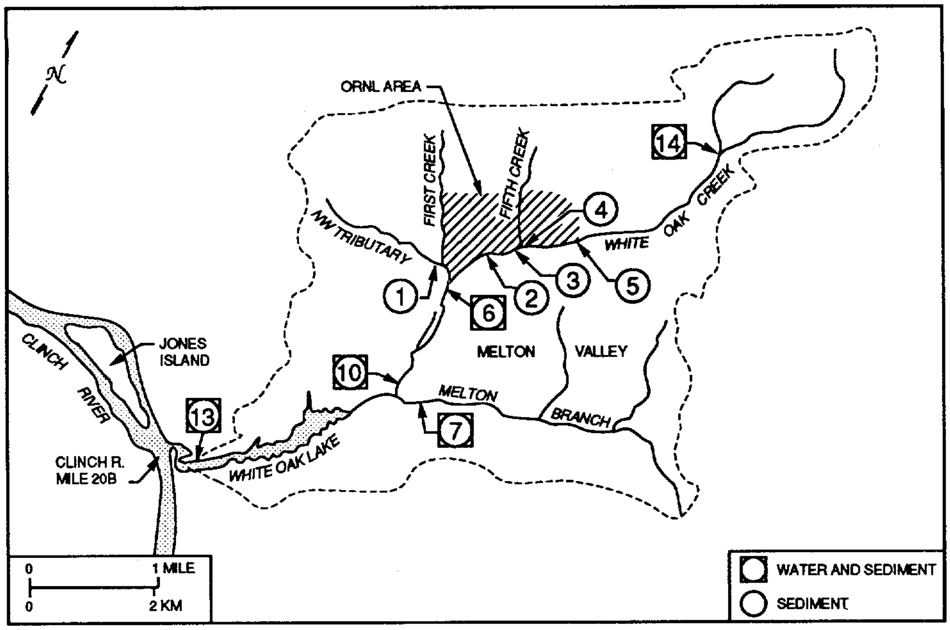

Fig. 3.14. Sample locations for PCB and TOC (sediment only) analyses in the ORNL area.

ORNL-DWG 90M-5776R

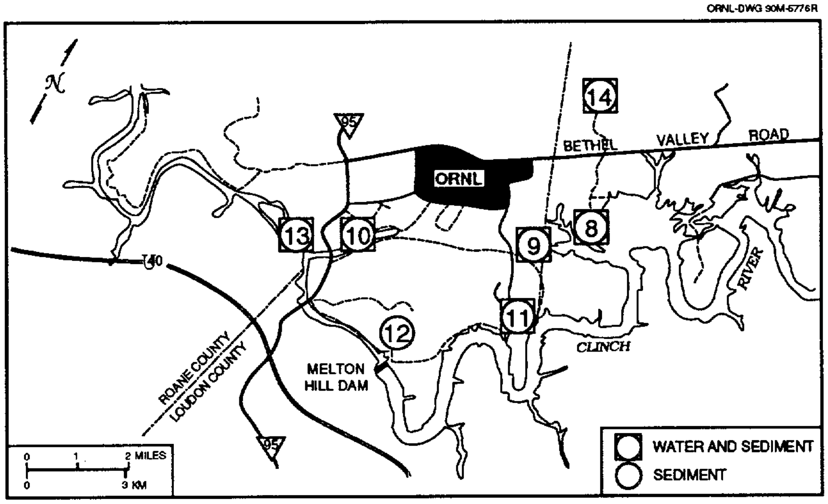

Fig. 3.15. Sample locations for PCB and TOC (sediment only) analyses in the greater ORNL area.

Table 3.35. Summary of ORNL PCB concentrations detected in sediment in the ORNL area, 1990

Analysis	Number detected	Number of samples	Concentration (μg/kg)			
			Max	Min	Av	Standard error[a]
Aroclor-1016	1	36	240	240	240	
Aroclor-1242	6	36	300	210	250	13
Aroclor-1254	3	36	2000	490	1200	430
Aroclor-1260	3	36	640	390	500	72
Aroclor-1221	0	36				
Aroclor-1232	0	36				
Aroclor-1248	0	36				

[a]Standard error of the mean.

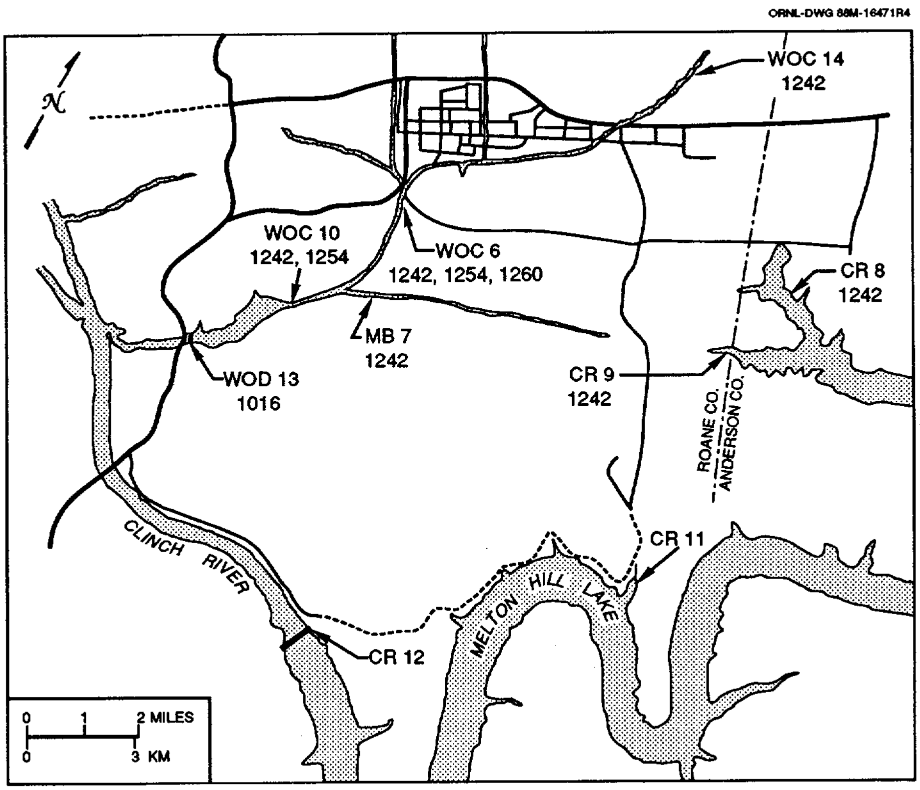

Fig. 3.16. PCB sampling locations and Aroclors detected.

Drive) identified the same compound at 0.13 and 0.59 µg/L. The suspect nature of these data are confirmed in the background (Station 14) concentration of 0.8 µg/L. During the same sampling period Aroclor-1242 was indicated at Station 1 (confluence of Northwest Tributary and First Creek) at 2.1 µg/L. Aroclor-1248 was identified at Station 4 (White Oak Creek below Fifth Creek) and Station 5 (White Oak Creek south of the 6000 area) at concentrations of 2.8 and 2.1 µg/L, respectively.

Of the 252 sediment samples, PCBs were detected in 13 samples (5%). Aroclors 1016, 1242, 1254, and 1260 were the mixtures detected. Location of the detects are shown in Fig. 3.16, and the data are summarized in Table 3.35. Aroclor-1016 was present at Station 13 (White Oak Dam) at a concentration of 240 µg/kg. Aroclor-1242 was identified at Stations 6, 7, 8, 9, 10, and 14 (Fig. 3.16) in concentrations ranging from 210 to 300 µg/kg (Table 3.35). The heavier compounds usually associated with transformer oils (Aroclors-1254 and 1260) were present at Stations 6 and 10. The greatest concentrations among all Aroclors were 1200 and 2000 µg/Kg below the confluence of Northwest Tributary and First Creek with White Oak Creek.

Because total organic carbon (TOC) is a direct measure of the organic carbon present, the relationship of TOC and PCB was investigated as a possible indicator of PCB in the first quarter. The first quarter minimum was 0.75%, as compared with a maximum of 8.1% and a mean of 2.8%. A correlation between TOC and sediment PCB concentration was not possible, because PCBs were not detected in 95% of the samples.

GROUNDWATER

4. GROUNDWATER

The quality of our nation's water resources is seen as a serious and pressing issue, and public awareness of the need to protect these resources has increased dramatically in the last decade. Public sentiment is reflected in legislation enacted by Congress mandating that actions be taken to preserve water resources from contamination. These statutes have been codified into regulations by the EPA and equivalent programs on the state level. Two such programs promulgated by Congress and administered by the state of Tennessee and the EPA are RCRA and CERCLA. Specifically targeting the protection of groundwater from contamination by hazardous wastes, these regulations guide groundwater monitoring at the DOE plants in Oak Ridge.

Groundwater suitable for most uses is potentially available nearly everywhere in Tennessee. About 51% of Tennessee's population depends on groundwater for household use. Most groundwater use occurs in the western quarter of the state; however, interest in additional development of groundwater resources is increasing in middle and eastern Tennessee (*National Water Summary 1986*). To date, no systematic study of the number of groundwater users in the immediate vicinity of the ORR has been conducted. However, it is known that in rural areas the number of individuals dependent on groundwater resources is substantial.

4.1 REGULATORY REQUIREMENTS

4.1.1 RCRA Interim Status and Permit Monitoring Programs

RCRA, as amended, recognizes three distinct programs that require groundwater studies: RCRA interim status, RCRA permit programs, and the RCRA 3004(u) program. Interim status requirements apply to facilities that treat, store, or dispose of hazardous waste if the facilities existed on November 19, 1980, or if the facilities became subject to permitting requirements because of new regulatory requirements. The facilities remain in interim status until a Part B operating or postclosure permit is issued. Two types of groundwater monitoring may be required while a facility is under interim status:

- Detection monitoring [defined in 40 CFR 265.91 and 40 CFR 265.92, and TN 1200-1-11-.05(6)] may be required to determine if hazardous waste or hazardous waste constituents have entered the groundwater underlying the facility.
- Assessment monitoring [defined in 40 CFR 265.93(a) and TN 1200-1-11-.05(6)(d)] will then be required to define the rate, extent, and concentration of hazardous waste or hazardous waste constituents that have entered the groundwater from a facility suspected of or known to be leaking.

Interim status facilities must file a Part B operating permit application or postclosure permit application to the regulatory authority. At the time of issuance of the permit, a facility shifts from an interim status monitoring program to the appropriate permit monitoring program required in the facility permit, as illustrated in Fig. 4.1. Where no groundwater contamination has been found, detection monitoring will continue with minor modifications [40 CFR 264.98 and TN 1200-1-11.06(b)(i)]. Sites with groundwater contamination will begin either compliance monitoring or corrective action monitoring depending on whether an approved corrective action plan is ready to be implemented.

4.1.1.1 RCRA 3004(u) monitoring program

Section 3004(u) was added to RCRA as an amendment in 1984 to require corrective action for all releases of hazardous constituents from any solid

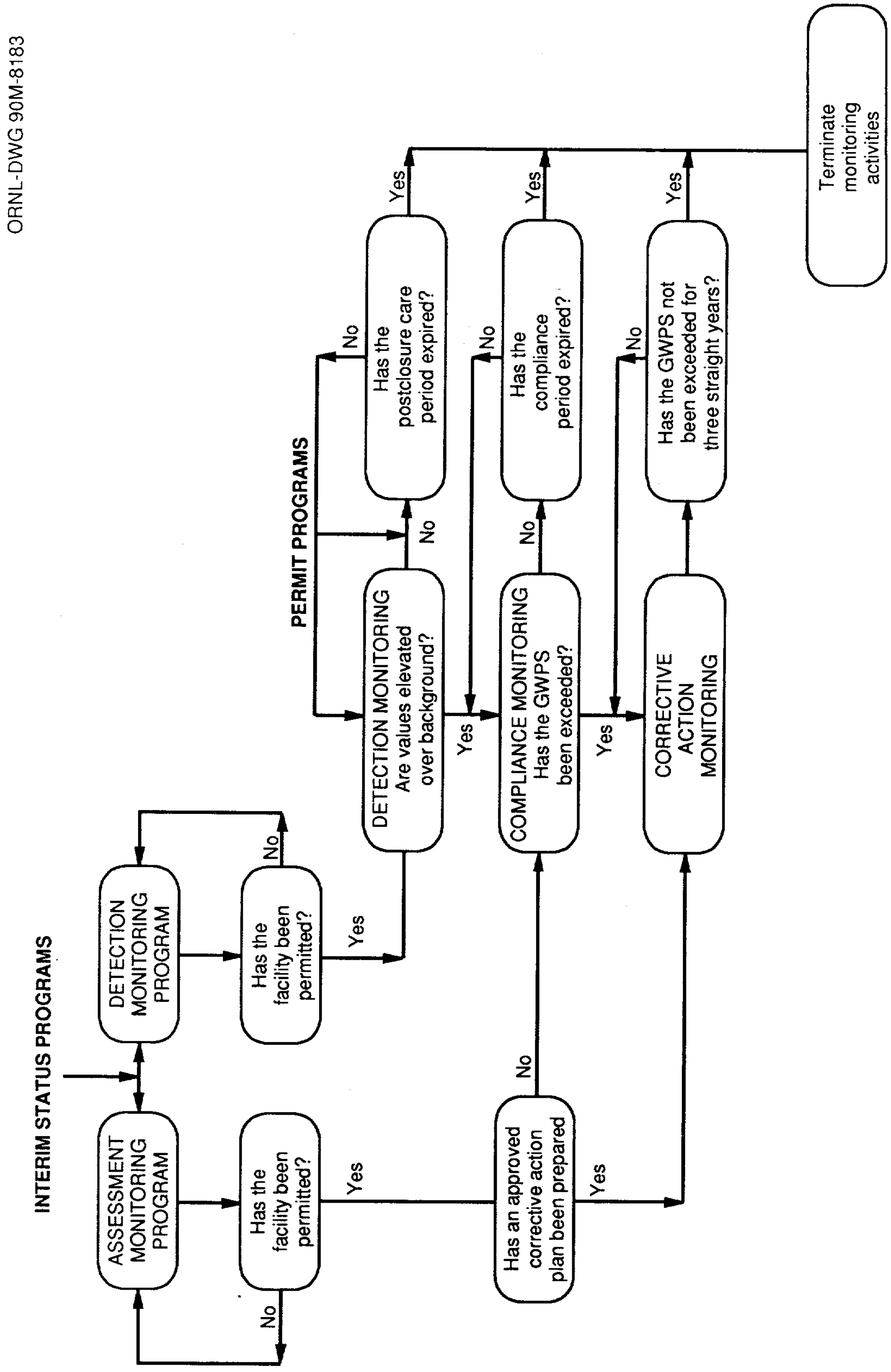

Fig. 4.1. Relationship between interim status monitoring and permit monitoring programs.

waste management unit at any facility seeking a permit. The 3004(u) program requires that sites be characterized to determine whether a threat to human health and/or the environment exists. Should a review of available data indicate a potential for contamination, groundwater monitoring would be necessary to evaluate that medium as an exposure pathway and for design of corrective measures.

The regulatory status and pertinent data regarding the current groundwater monitoring program being conducted at each hazardous waste unit are summarized for the Y-12 Plant, ORNL, and the K-25 Site in later sections of this report.

4.1.2 Groundwater Surveillance Monitoring Program on the ORR

The technical objectives of groundwater monitoring under either the detection or assessment monitoring programs are similar in nature:

- collect piezometric head (water level) measurements to estimate the direction of groundwater flow;
- obtain representative water samples from the geologic strata;
- determine the reference water chemistry of each hydrogeologic unit from analysis of samples collected upgradient of waste disposal areas;
- evaluate the current impact of waste disposal activities on the groundwater through a comparison of analyses from samples collected upgradient and downgradient of the disposal area;
- identify the hazardous waste or hazardous waste constituent(s) present should contamination be detected; and
- delineate the extent of contamination and the rate of migration.

The groundwater surveillance monitoring program being implemented at the DOE facilities has been designed to obtain full compliance with regulatory requirements and the aforementioned technical objectives. Site-specific regulatory monitoring programs are supported technically by site characterization and regional studies of the geohydrologic and chemical aspects of the flow system. Quality control procedures for every aspect of data collection and analysis have been established, and data bases are used to organize and distribute analytical results.

Thus, the groundwater surveillance monitoring program for the ORR, while disposal site- and facility-specific, contains a number of common components (Fig. 4.2) that are interrelated and coordinated to allow both time- and cost-effective project management.

4.2 HYDROGEOLOGY

Subsurface materials on the ORR can be hydrologically classified into a near-surface stormflow zone, a vadose (i.e., unsaturated) zone, and a groundwater zone (Fig. 4.3). The stormflow zone approximately corresponds with the root zone of vegetation and is 0.5 to 1.5 m thick. Many rainfall events produce a transient, perched water table in the stormflow zone, and water is then transmitted downslope to nearby streams. Water storage is intergranular, but lateral flows occur through macropores and mesopores (>0.2 mm diameter). The stormflow zone is nearly drained 5–15 days after a rainfall event.

The permanent water table occurs near the regolith and bedrock contact at depths of 1–50 m. The rock is impermeable, and groundwater flows through fractures and a few cavities. A layer where permeable fractures are connected in three dimensions occurs near the water table. This layer is recharged by percolation through the vadose zone and is partly drained between recharge events. At deeper levels, a few permeable fracture intervals occur within a relatively impermeable matrix. The average hydraulic conductivity of the permeable intervals is two to three orders of magnitude larger than that of the matrix intervals.

The land surface is very permeable on the ORR, and most precipitation infiltrates. Overland runoff occurs mainly on wetlands (i.e., saturated soils), impermeable areas, and water bodies; together these occupy an average 2–3% of the stream basins. About 76 cm/year of the total precipitation replenishes soil water deficits and is later consumed by evapotranspiration. The remaining 59 cm/year of water leaves the ORR as streamflow. Overland runoff, stormflow, and nearly all groundwater flow downslope to a nearby stream. Small amounts of groundwater follow deeper paths, but interbasin flows of groundwater have not been observed on the ORR. Most springs are wet-weather types, and changes in

ORNL-DWG 90M-8184

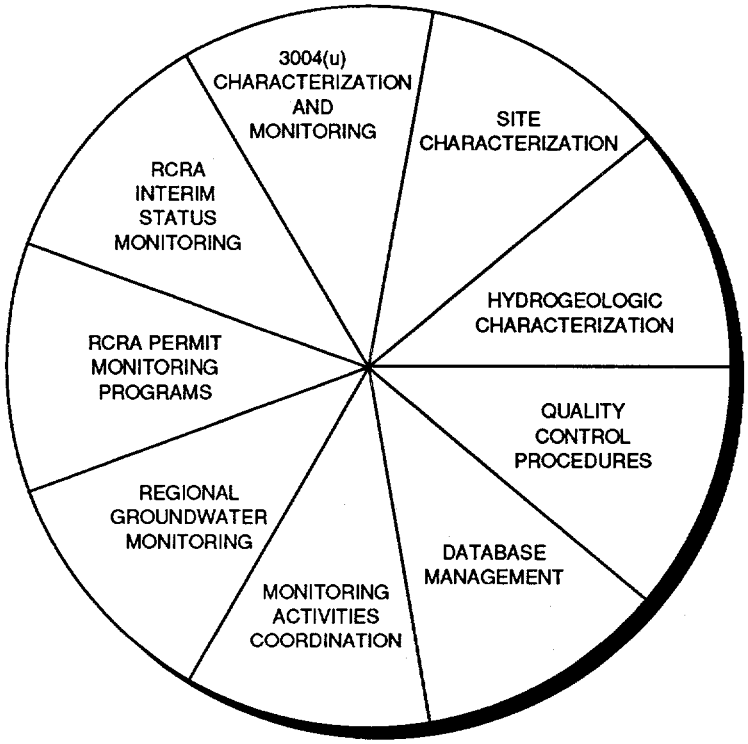

Fig. 4.2. Components of Oak Ridge Reservation groundwater surveillance program.

streamflow are accompanied by changes in channel length.

4.2.1 Stormflow Zone

The total porosity of the stormflow zone is about 0.30–0.50 (Davis et al. 1984; Peters et al. 1970), but hydrograph analysis in the headwaters area of Melton Branch and in Ish Creek basin shows that the average specific yield is only about 0.03–0.05. This range in specific yield is probably typical of the ORR. The average permeability of the stormflow zone is determined mostly by macropores and mesopores. Both infiltration tests and hydrograph analysis show that the average hydraulic conductivity of a forested watershed is about 6.0–12 m/d, and average transmissivity near the time of a hydrograph peak is about 4–8 m^2/d. In grass-covered areas, for contrast, the average hydraulic conductivity is about 1.1 m/d and maximum transmissivity may be about 0.3 m^2/d. The average hydraulic gradient is 0.075, the same as the average slope of land surface. Peak discharge rates from the stormflow zone typically are about 80–110 L/s·km^2 of forested drainage area. These discharge rates decrease to 25–30 L/s·km^2 after 4 d of recession from a hydrograph peak and <10 L/s·km^2 of drainage area after 10 d of recession.

Discharge from the stormflow zone is an important component of streamflow in the ORNL area. In areas underlain by the Rome Formation, the Conasauga Group, and the Chickamauga Group, however, the permanent water table drops below the stream channels during the growing season; nearly all of the subsurface waters are consumed by evapotranspiration; and nearly all natural streamflow consists of short periods of overland runoff from impermeable areas and wetlands. During the nongrowing season, streamflows are better sustained and consist, successively, of overland runoff, stormflow discharge, and groundwater discharge. Discharge from the stormflow zone constitutes nearly all streamflow after 15–30 h of recession from a hydrograph peak, but discharge from the groundwater zone is dominant after 8–10 d of recession.

In areas underlain by the Knox aquifer (the Knox Group and the Maynardville Limestone of the Conasauga Group), less overland runoff occurs, and the stormflow zone rarely fills to overflowing because of larger percolation rates to the permanent

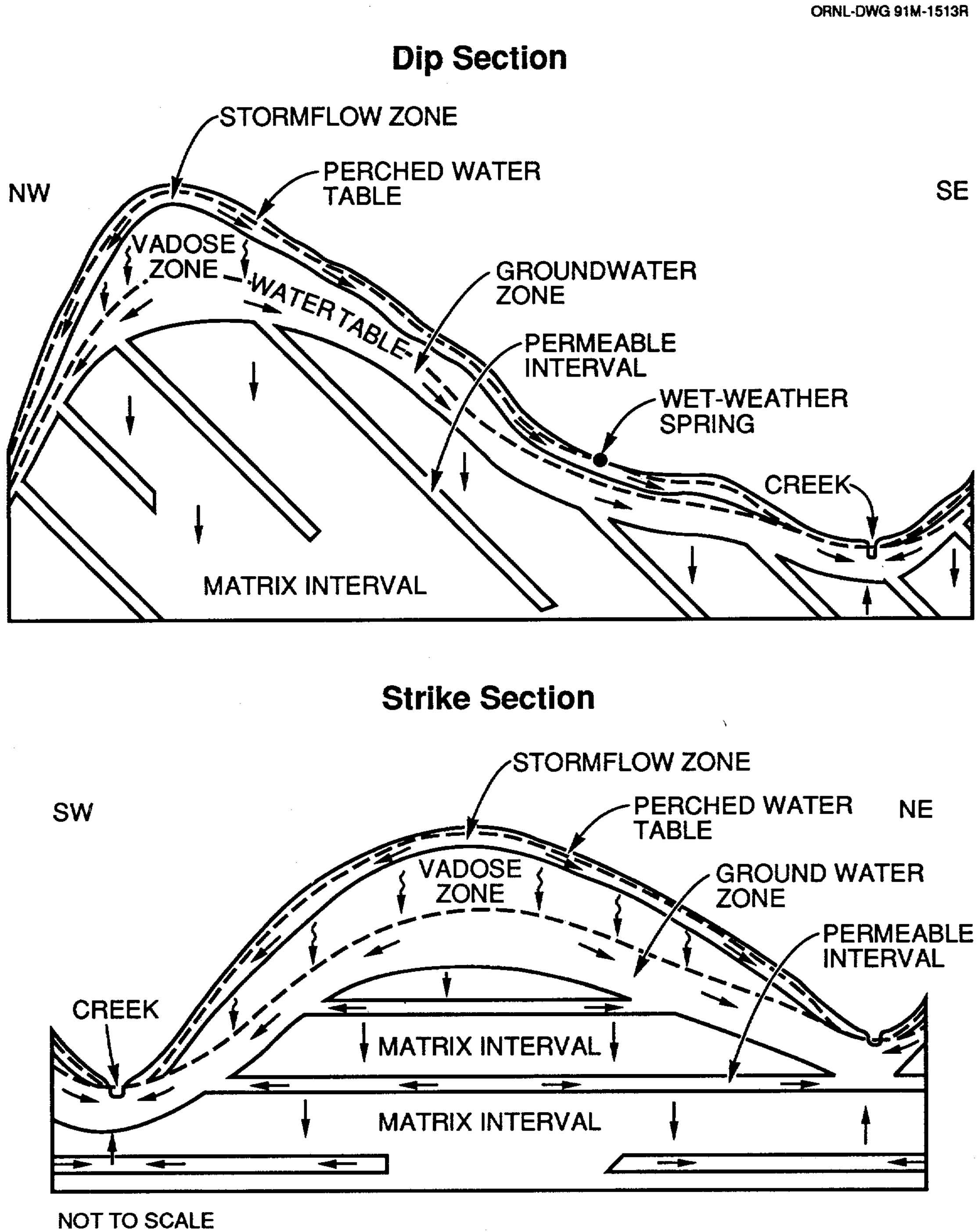

Fig. 4.3. Sections showing subsurface zones and directions of water flow.

water table. Also, the water table does not fall below the stream channels; stormflow discharge is intermittent, but groundwater discharge is continuous through the growing season, which sustains base streamflows. During the nongrowing season, discharge from the stormflow zone constitutes nearly all streamflow after 10–20 h of recession from a hydrograph peak, and groundwater discharge is dominant after 6–8 d of recession.

4.2.2 Groundwater Zone

Most groundwater flows through the permeable layer near the water table, and this layer is partly to nearly drained during dry periods. Spatial and temporal differences in the saturated thickness and transmissivity of this layer explain the configuration of the water table and most of the fluctuations in groundwater discharge to streams. The water table is near the contact between regolith and weathered bedrock because a large water flux has formed regolith at shallower levels by solution of the rock cement. Seasonal changes in water table elevation change the saturated thickness of this layer. The resulting changes in transmissivity explain an orders-of-magnitude fluctuation in groundwater discharge rates even though (1) contours of water table elevation at the times of annual high and low water levels show little change in hydraulic gradients, and (2) the seasonal changes of water level in most wells are small compared with heights above stream level. Increased hydraulic gradient with decreased saturated thickness from one physiographic location to another is consistent with the common observation that the water table is a subdued replica of land surface.

Progressively less water reaches deeper levels in the groundwater zone because of lateral water flows at each shallower permeable interval. Groundwater is unconfined near the water table, but a gradual change to confined conditions occurs at deeper levels. Flowing wells occur in a few areas. The base of active groundwater circulation occurs at a depth of 30–90 m and is characterized by (1) a change from a calcium bicarbonate to a sodium bicarbonate or a sodium carbonate water type, (2) an absence of tritium and any pollutants at deeper levels, and (3) a corrected (factors other than matrix diffusion) carbon-14 age of >5000 years. These changes are gradational in some areas.

Fifteen tests with an electromagnetic borehole flowmeter showed that the average thickness of the permeable intervals is about 60 m. Well logs and an analysis of the depths of paired shallow and deeper wells show that the vertical spacing between permeable intervals increases from 7 m near the water table to >35 m at depths below 60 m. Hydrograph analysis shows that specific yield near the top of the groundwater zone is about 0.0025 in areas underlaid by the Rome Formation, Conasauga Group, and Chickamauga Group, and is 0.0033 in areas underlaid by the Knox aquifer. The geometric mean of storativity from 50 aquifer tests, mostly at deeper levels, is 0.00084, and this value is only a little smaller than the calculated specific yields. These results show that specific yield, effective porosity, and storativity are nearly the same in the fractured rocks of the ORR.

The geometric means of transmissivity for 760 aquifer tests are 0.23 m^2/d for permeable intervals and 0.0011 m^2/d for matrix intervals. If the borehole flowmeter surveys are interpreted to show that permeable intervals have an average thickness of 0.60 m and if the matrix intervals are assumed to be uniformly relatively impermeable, then the hydraulic conductivity of the permeable intervals is >1000 times larger than that of the rock matrix.

Hydrograph analysis in the Melton Branch watershed near the time of annual high water levels in wells shows a total transmissivity of 0.75 m^2/d for all permeable intervals. This result may be typical for areas underlain by the Rome Formation, Conasauga Group, and Chickamauga Group. Similar calculations for the Ish Creek basin, which is underlain by the Knox aquifer, show a total transmissivity of 3.7 m^2/d. The average hydraulic gradient is about 0.05, and the range is from about 0.007 on floodplains to about 0.1 on steep hillsides. Peak groundwater discharge rates are about 4.7–17 $L/s{\cdot}km^2$ of drainage area. The discharge rates decrease to 2.9–12 $L/s{\cdot}km^2$ of drainage area after 4 d of recession from a hydrograph peak and to 1.4–7.4 $L/s{\cdot}km^2$ of drainage area after 10 d of recession.

4.3 GROUNDWATER MONITORING WELL SYSTEMS

The ORR has more than 1000 groundwater monitoring wells. Because of the enormous volume of data taken annually from these wells, only the results for detected analytes and results that do not meet applicable standards are shown in this report. Tables 4.1–4.11 in Vol. 2 outline the applicable standards. Tables 4.12–4.24 in Vol. 2 provide data summaries for the various groundwater sampling programs.

4.3.1 Oak Ridge Y-12 Plant

4.3.1.1 Background

The Y-12 Plant poses unique and challenging problems to the development and implementation of a comprehensive monitoring program. Historically, data have been collected to meet several objectives: monitoring to meet permit requirements; characterization at or surrounding particular waste sites; detection and assessment monitoring to meet RCRA regulatory requirements; and, finally, monitoring to determine the overall water quality and flow patterns in the area. Data collected to date suggest the intermingling of contaminate releases from multiple unrelated waste sites that are regulated by overlapping regulatory programs. To address the various objectives for the collection of data and to ensure a technical consistency to the data collection and evaluation process, the Y-12 Plant Comprehensive Groundwater Monitoring Plan has been developed and is being implemented. The basis for the development of this plan is the hydrogeologic systems that control the rate of transport of contaminants. In this plan, the Y-12 Plant has been subdivided into three distinct hydrogeologic regimes based on topography, surface water drainage, and groundwater flow patterns.

The Y-12 Plant is located in Bear Creek Valley, which is flanked on the north by Pine Ridge and on the South by Chestnut Ridge. To assess groundwater quality at the Y-12 Plant, Bear Creek Valley has been divided into the Bear Creek Hydrogeologic Regime (BCHR) and the Upper East Fork Poplar Creek Hydrogeologic Regime (UEFPCHR). A topographic and hydrogeologic divide located near the west end of the Y-12 Plant separates the two hydrogeologic regimes. The Chestnut Ridge Hydrogeologic Regime (CRHR) is designated as the third hydrogeologic regime.

Since 1987 the Y-12 Plant has issued Groundwater Quality Assessment Reports (GWQARs) to the TDC as required for RCRA Interim Status units in assessment monitoring. These reports have been used as a forum to present data, data interpretations, and monitoring program modifications. Beginning in 1989, the format for issuing these reports was modified such that a GWQAR was issued for each hydrogeologic regime. Moreover, the 1989 GWQARs were completed in two parts for BCHR and UEFPCHR. Part I contained all the assessment data obtained in the previous calendar year, along with a calculated rate of migration, and was submitted to the TDC by the March 1 reporting deadline. The evaluation and interpretation of the assessment data was included in Part II of the GWQAR, which was submitted to the TDC in June 1990. This two-part reporting convention has been continued for the 1990 assessment data. The GWQAR for Chestnut Ridge was issued as a single document and addressed groundwater contamination at the Chestnut Ridge Security Pits, the only confirmed source of groundwater contamination in the CRHR.

4.3.1.2 Program modifications implemented in 1990

Components of the comprehensive groundwater monitoring program at the Y-12 plant for 1990 are summarized in Table 4.1. Analytical analyses completed in 1990, which represent a 44% increase in the number of parameters reported over the same reporting period for 1989, are summarized in Table 4.2.

In addition to the previously discussed reporting changes, other modifications to the assessment monitoring program were proposed in Part II of the 1989 GWQAR for implementation in 1990. These modifications included the following:

- monitoring for a standardized list of assessment parameters;
- establishing a definite sequence in which monitor wells were to be sampled;
- installing additional monitoring wells and sampling of United States Geologic Survey (USGS) wells at the plant's perimeter;
- including selected surface water sampling locations in the assessment program; and
- initiating a dye-tracer study at Chestnut Ridge Security Pits.

Groundwater samples collected during the 1990 assessment monitoring program were analyzed for the

Table 4.1. Summary of the groundwater surveillance program at the Y-12 Plant, 1990

Unit name	Current groundwater monitoring program									
	Regulatory status	Interim status		Permit				Parameters monitored[a]	Monitor wells	Sampling frequency
		Detection	Assessment	Detection	Compliance/ corrective action	Operating	3004(u)			
Bear Creek Hydrogeologic Regime										
Bear Creek Burial Grounds										
Burial Grounds	RCRA	1985	1986	*b*			*b*	Standard +U+PHE	59	Quarterly
LLWDDD Lysimeter Demonstration Site								Standard	9	Quarterly
LLWDDD Packaging Site								Standard	6	Quarterly
Oil Landfarm Area	RCRA	1985	1986	*b*			*b*	Standard +U+TC	39	
Rust Spoil Area	3004(u)	*b*		*b*			1987	Standard +SR+H3+C137 +I129+TC	7	Quarterly
S-3 Ponds										
S-3 Ponds	RCRA	1985	1986	*b*			b	Standard +TC+U+PU+NP +AM+SR+H3	39	Quarterly
Spoil Area I	3004(u)	*b*		*b*			1987	Standard	6	Quarterly
Surface water and sediment								Standard+U	10	Quarterly
USGS-1S/Chestnut Ridge								Standard	2	Quarterly

Table 4.1 (continued)

Unit name	Current groundwater monitoring program									
	Regulatory status	Interim status		Permit				Parameters monitored[a]	Monitor wells	Sampling frequency
		Detection	Assessment	Detection	Compliance/ corrective action	Operating	3004(u)			
Upper East Fork Poplar Hydrogeologic Regime										
Beta-4 Security Pits[c]	3004(u)	*b*		*b*			1985	Standard+U	6	Quarterly
New Hope Pond	RCRA[d]	1985	1988	*b*			*b*	Standard +TC+U+SR+H3	21	Quarterly
S-3 Ponds										
S-3 Ponds	RCRA	1985	1986	*b*			*b*	Standard+TC	6	Quarterly
Salvage Yard/OSDS[c]	3004(u)	*b*		*b*			1985	Standard+U	7	Quarterly
S-2								Standard+TC	2	Quarterly
Underground Storage Tank Investigation										
9201-1								Standard+TPH	1	Quarterly
9204-2								Standard+TPH	1	Quarterly
9754-2 Fuel Facility								Standard+TPH	1	Quarterly
Salvage Yard/OSDS[c]	3004(u)	*b*		*b*			1985	Standard+TPH	1	Quarterly
Rust Garage Area								Standard+TPH	2	Quarterly
Waste Coolant Facility								Standard	7	Quarterly
9754-2 Fuel Facility								Standard+U+TPH	5	Quarterly

Table 4.1 (continued)

Unit name	Regulatory status	Interim status		Permit				Parameters monitored[a]	Monitor wells	Sampling frequency
		Detection	Assessment	Detection	Compliance/ corrective action	Operating	3004(u)			
					Chestnut Ridge Hydrogeologic Regime					
Chestnut Ridge Security Pits	RCRA	1985	1988	*b*			*b*	Standard+U	17	Quarterly
Chestnut Ridge Sediment Disposal Basin	RCRA	1985		*b*			*b*	Standard+U+BNA	8	Quarterly
E. Chestnut Ridge Waste pile	RCRA	*b*				1988	*b*	Standard	4	Quarterly
Fly Ash Pond	3004(u)	*b*		*b*				Standard +TOC+TOX	4	Quarterly
Industrial Landfill III	3004(u)	*b*		*b*			1988	Standard+U	7	Quarterly
Industrial Landfill IV	3004(u)	*b*		*b*			1988	Standard+U	5	Quarterly
Kerr Hollow Quarry	RCRA	1985		*b*			*b*	Standard +TOC+TOX+PHE	7	Quarterly
Rogers Quarry[c]	3004(u)	*b*		*b*			1985	Standard	4	Annual
Sanitary Landfill II						1986		Standard	3	Quarterly
United Nuclear Landfill	3004(u)	*b*		*b*			1985	Standard+U	7	Quarterly

Table 4.1 (continued)

Unit name	Current groundwater monitoring program									
	Regulatory status	Interim status		Permit				Parameters monitored[a]	Monitor wells	Sampling frequency
		Detection	Assessment	Detection	Compliance/ corrective action	Operating	3004(u)			
Perimeter wells										
East								Standard+U	7	Quarterly
West								Standard+U	3	Quarterly

[a]Standard: Standard Monitoring Program
- Cadmium, chromium, and lead by Atomic Absorption Spectometry
- Volatile organics
- Elemental analyses by Inductively Coupled Plasma
- Mercury
- Gross alpha and gross beta
- Fluorometric uranium
- Field measurements: conductivity, pH, redox, dissolved oxygen, and temperature
- Inorganics and miscellaneous parameters:
  - pH, conductivity, TSS, TDS, turbidity, alkalinities, chloride, nitrate-N, sulfate, fluoride
- Additional parameters:
  - Tc: 99 Technetium
  - U: Isotopic uranium (^{234}U, ^{235}U, ^{238}U)
  - Pu: 239 Plutonium
  - Np: 237 Neptunium
  - Am: 241 Americium
  - Sr: Strontium
  - ^{3}H: Tritium
  - ^{137}C: 137 Cesium
  - ^{129}I: 129 Iodine
  - TPH: Total petroleum hydrocarbons
  - BNA: Semi-volatile organics
  - TOC: Total organic carbon
  - TOX: Total organic halide
  - PHE: Phenols

[b]Not applicable.
[c]Wells installed for plant site characterization program; authority transferred to 3004(u) in 1986.
[d]Site is treated like a RCRA site.

Table 4.2. Summary of Y-12 Plant groundwater analyses during 1990

Analytical reported procedure	Number of samples run	Number of items
Elemental Analyses		
ICAP	1,718	42,950
AAS	1,960	6,430
HG	1,826	1,826
U	2,002	2,002
Inorganic analyses	1,001	8,982
Phenols	142	142
Organics		
Volatile	975	33,186
Acid/base-neutral	58	3,770
Herbicides, pesticides, and PCBs	31	811
Field measurements	1,008	5,908
Laborator replicates		
Conductivity and pH	1,001	3,566
TOC and TOX	178	1,358
Radiochemical analyses		
Gross alpha and beta	988	1,976
Radium	98	118
Isotopic uranium	209	624
Alpha emitters	16	16
Beta emitters	87	243
Total	13,298	113,908

parameters and constituents shown in Table 4.1. This list was prepared from 1986 base program monitoring data and assessment data collected in 1987, 1988, and 1989. It reflects efforts to concentrate the assessment program on actual groundwater contaminants (i.e., those constituents detected at concentrations above background levels or in excess of applicable water quality standards), as well as to establish a standardized suite of analytical parameters for all samples collected at the Y-12 Plant. Additional uranium isotopic data and radiochemical measurements were taken at selected sites to further define background water quality and confirm previous results. A standard suite of trace metals were routinely analyzed by inductively coupled plasma (ICP). The analysis of some metals including arsenic, selenium, and lead are subject to interferences when analyzed by ICP. The interferences are usually caused by high iron and aluminum concentrations that are ubiquitous in soil and rock and are naturally present in most groundwaters. Therefore, ICP data are not considered conclusive for these elements unless confirmed by a second analysis, atomic absorption (AA). The AA analysis is often necessary to meet detection limits for regulatory standards. Historical AA data indicate that lead is present in some Y-12 Groundwaters. Thus, lead continues to be analyzed by AA. On the other hand, arsenic and selenium continued to be monitored via ICP for program consistency, although evaluation of previous years AA data has not confirmed these elements to be present in concentrations above background.

To minimize the potential for cross contamination between wells, samples were collected in the predetermined sequence that reflects a protocol of sampling from background wells to the most contaminated wells at a given site. Several new monitoring wells have been installed in the BCHR and UEFPCHR to help delineate contaminant plume boundaries, and to establish an exit-pathway monitoring well network. Exit-pathway monitoring wells were completed at various depths in the Maynardville Limestone, which is believed to be the principal conduit for contaminant migration in the BCHR. The screened interval of these wells was set to intersect specific stratigraphic zones thought to be more susceptible to solution cavity development. The down-dip extensions of those zones were specifically targeted as they would be the most likely pathways for transport in deeper portions of the Maynardville Limestone.

The quarterly collection of surface water samples from Bear Creek was also included in the 1990 assessment program. Surface water samples were analyzed for the standard list of parameters. Background surface water samples were collected from one site (NT-13), located in a tributary to Bear Creek, that has not been impacted by waste management activities in the Bear Creek Valley Waste Disposal Area (BCVWDA). Four downstream sampling locations were also included: BCK 0.63, BCK 4.55, BCK 9.4, and BCK 11.97. The rationale for the selection of these sampling locations is provided in Table 4.3.

4.3.1.3 Waste site descriptions

Background information regarding the waste sites located within each hydrogeologic regime is provided in the following subsections. A description of each site and a short narrative regarding the history of assessment activities are presented.

Upper East Fork Poplar Creek Hydrogeologic Regime

Four basic categories of sites are located in the UEFPCHR: (1) an RCRA interim status T/S/D unit (New Hope Pond), (2) SWMUs located within the Waste Management Area (WMA) of an RCRA interim status T/S/D unit, (3) SWMUs that are not located within the WMA of any T/S/D unit, and (4) USTs. Sites located in the UEFPCHR that are addressed in this document are listed in Table 4.4.

Table 4.3. Description of surface-water monitoring stations included in the Exit-Pathway Monitoring Program

Monitoring Station	Description
NT 13 (Background)	Tributary that enters Bear Creek at BCK 6.76 and represents drainage from a relatively undisturbed catchment that has not been impacted by waste-disposal activities in Bear Creek Valley.
BCK 0.63	Upstream of the confluence with East Fork Poplar Creek. Represents essentially all surface-water discharge from the Bear Creek watershed.
BCK 4.55	Location of NPDES monitoring site 304. Site represents surface-water discharge from at least one area of the Bear Creek floodplain known to be contaminated with uranium and PCBs.
BCK 9.40	Represents surface-water discharge from area of Bear Creek watershed impacted by waste-disposal activities.
BCK 11.97	Represents surface-water discharge from area of S-3 Site, Rust Spoil Area, and Spoil Area I. Includes discharge from Tributary NT-1 and Spring SS-1, which probably receives groundwater inputs from S-3 Site contamination.

Table 4.4. Waste sites included in the 1990 Assessment Program for UEFPCHR

Site	Regulatory classification[a]
New Hope Pond	RCRA T/S/D Unit
S-3 Waste-Management Area	
Rust Garage Area	SWMU/UST
Salvage Yard Drum Deheader	SWMU
Salvage Yard Tanks 2063-U, 2328-U, and 2329-U	SWMU
Salvage Yard Oil Storage Area	SWMU
Salvage Yard Oil/Solvent Storage Area	SWMU
Salvage Yard Scrap Metal Storage Area	SWMU
Interim Drum Yard	SWMU
S-2 Site	SWMU
Mercury Process Spill Areas	SWMU
Abandoned Nitric Acid Pipeline	SWMU
Beta-4 Security Pits	SWMU
Waste Coolant Processing Area	SWMU
Coal Pile Trench	SWMU
Building 81-10	SWMU
Garage Underground Tanks (formerly 9754 Fuel Facility)	SWMU/UST
9754-2 Fuel Facility	UST
Tank 2331-U	UST
Tank 0134-U	UST

[a]RCRA T/S/D Unit = RCRA regulated land-based treatment, storage, or disposal unit. SWMU = Solid Waste Management Unit. UST = Underground Storage Tank.

RCRA T/S/D unit

New Hope Pond

New Hope Pond (NHP), located in BCV at the east end of the Y-12 Plant (Fig. 4.4), was constructed in 1963 and operated until November 8, 1988, at which time water was diverted away from the pond to Lake Reality. The pond was designed to regulate the flow and quality of water in Upper East Fork Poplar Creek before it exits the Y-12 Plant and flows toward the city of Oak Ridge. The creek receives surface water runoff and flow from subsurface drains that collect discharges (primarily cooling water) from processes at the plant. While in operation, discharge from the pond averaged approximately 8 million gallons per day. Water quality sampling was performed in accordance with the conditions set forth in an NPDES permit.

In 1973, sediments from New Hope Pond were removed and placed in the Chestnut Ridge Sediment Disposal Basin (CRSDB). Since that time, sediment from the inlet diversion ditch was periodically removed and disposed of in the CRSDB. These sediments contained PCBs, mercury, and uranium, but extraction procedure (EP) toxicity analyses indicated that they did not exhibit the characteristics of a hazardous waste. Approximately 25,000 cubic yards of sediment remained in the pond when it was closed in 1988. Closure was completed in accordance with the standards defined for RCRA-regulated landfills. Sediments in the pond were stabilized by the addition of coarse aggregate, and the site was covered with a multilayered cap. Final closure of NHP was certified by the TDC on December 11, 1990.

Lake Reality was constructed immediately downstream of NHP and began operations on November 8, 1988. Water enters Lake Reality from an extension of the NHP inlet diversion ditch and is released into the existing channel of Upper East Fork Poplar Creek through a weir in the west berm. An emergency weir is located at the north end of the Lake Reality distribution ditch. The total surface area of Lake Reality is about 2.5 acres, and the average water depth is approximately 7 ft. During normal operations, Lake Reality contains approximately 6 million gallons of water.

Solid waste management units

Following are brief descriptions of the Solid Waste Management Units (SWMUs) located in the UEFPCHR at which groundwater monitoring was conducted during 1990. Most of these SWMUs are located near the western end of the UEFPCHR and are included within the S-3 Site WMA (Fig. 4.4); the S-3 Site lies just west of the groundwater and topographic divide that separates the BCHR and UEFPCHR. Other SWMUs located in the UEFPCHR are targeted for further investigation.

Rust Garage Area

The Rust Garage Area is located in the northwestern portion of the UEFPCHR about 650 ft east of the S-3 Site (Fig. 4.5). Building 9720-15, which houses the Rust Garage, is currently used to perform maintenance on vehicles and equipment. Industrial products containing hazardous constituents that are stored on-site include lubricating oil, gasoline, diesel fuel, hydraulic fluid, antifreeze, battery acid, and mineral spirits. A bulk-oil storage platform and an elevated gasoline tank are located south of the garage, and a wash pad is located on the east side of the building. In the past the site was also used as a sandblasting area.

Four underground fuel storage tanks with associated piping were located in the Rust Garage Area. Gasoline and diesel fuel releases associated with operation of the USTs have been reported. Temporary piezometers were installed during early 1988 to facilitate detection of the leaks, and free product was detected in at least one of these piezometers. Groundwater wells were installed at the site in 1990 as part of a UST site investigation.

Salvage Yard Sites

The Salvage Yard is located in the northwestern portion of the UEFPCHR (Fig. 4.5). Historically, it was composed of the Scrap Metal Storage Area, the Oil/Solvent Drum Storage Area, the Oil Storage Tanks, the Drum Deheader, and three concrete sumps designated tanks 2063-U, 2328-U, and 2329-U.

The Salvage Yard Scrap Metal Storage Area has been used since 1950 for the storage of scrap metal, some of which contains low levels of depleted or enriched uranium. Some minor contamination of surficial soils at the site has been reported.

The Salvage Yard Oil/Solvent Drum Storage Area consisted of the east drum storage area and the west drum storage area. Each area has been closed as described in the RCRA closure plan for the respective area. The combined total storage capacity of both areas was approximately 175,000 gal. Waste oils containing chlorinated organics, uranium, and/or beryllium; chlorinated organic solvents; and nonchlorinated flammable solvents have been stored in drums on-site. Leaking drums and spills have been documented. Although a dike was present around the downslope side of the site, the gravel/soil base of the dike may have permitted infiltration of spilled material into the subsurface.

Operation of the Salvage Yard Oil Storage Tanks began in 1978 when a 6000-gal tank was installed to store PCB-contaminated oil. A 5000-gal tank was added to the site in 1980. Both tanks were contained within an earthen dike and were emptied in 1986. Spills and leaks have occurred but were contained within the diked area.

The Salvage Yard Drum Deheader was operated from 1959 to 1989 and was used to cut off the tops and crush empty drums collected from various locations throughout the Y-12 Plant. The facility is contained within a small shed with a concrete floor. Prior to deheading, the contents of the drums were routinely emptied into other drums contained within a small sump (Tank 2063-U). Tank 2063-U was about 2 ft wide, 4 ft long, 2 ft deep, and had a total capacity of about 130 gal. Spills and overflows that occurred when the liquids were poured into the storage drums were contained in Tank 2063-U and subsequently transferred through a connecting drainpipe to other sumps designated Tanks 2328-U and 2329-U. Liquids still present when the drums were deheaded flowed

ORNL-DWG 90M-8014R

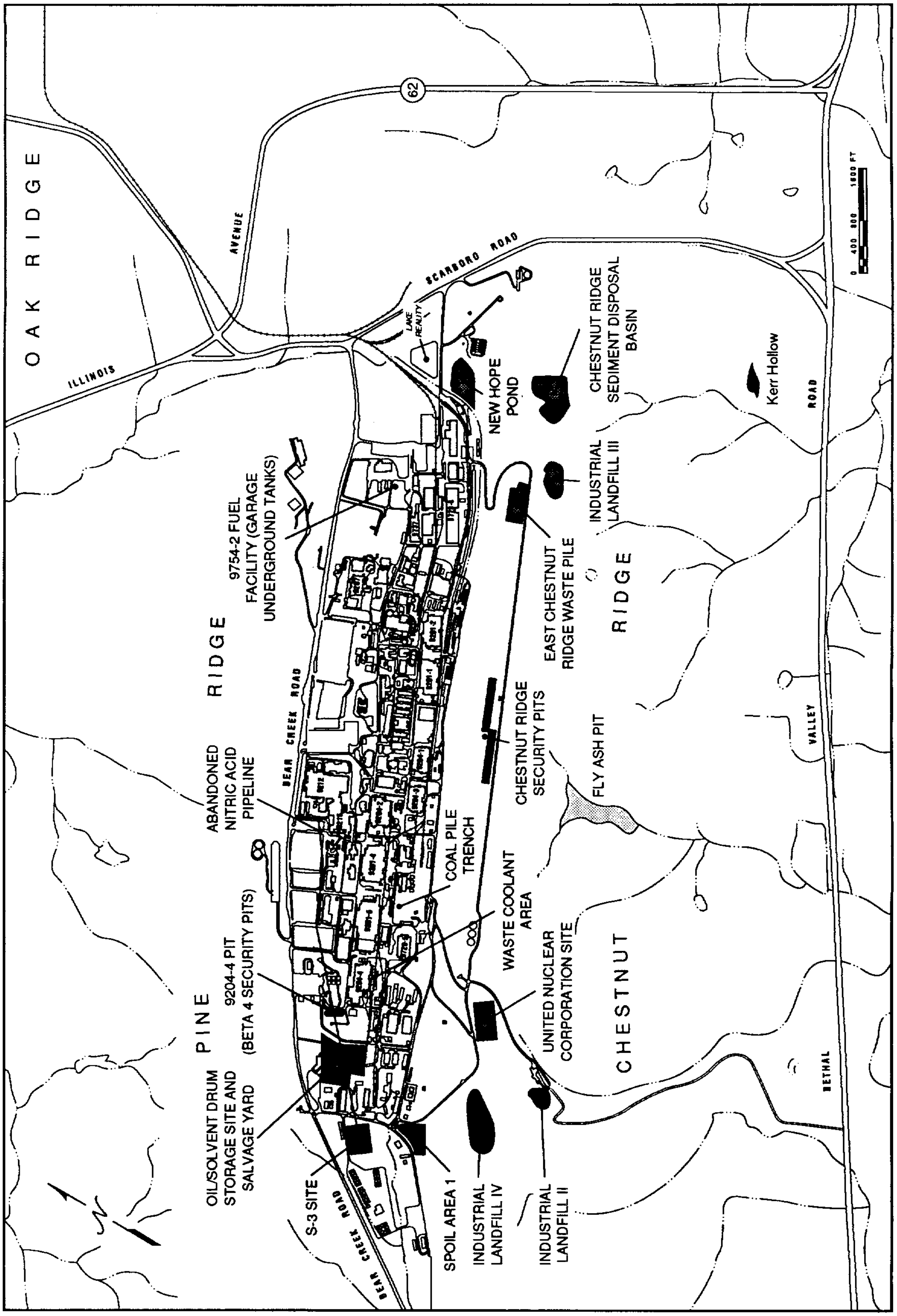

Fig. 4.4. Index maps of Y-12 Plant comprehensive groundwater characterization program by sites (part 1).

ORNL-DWG 90M-8014AR

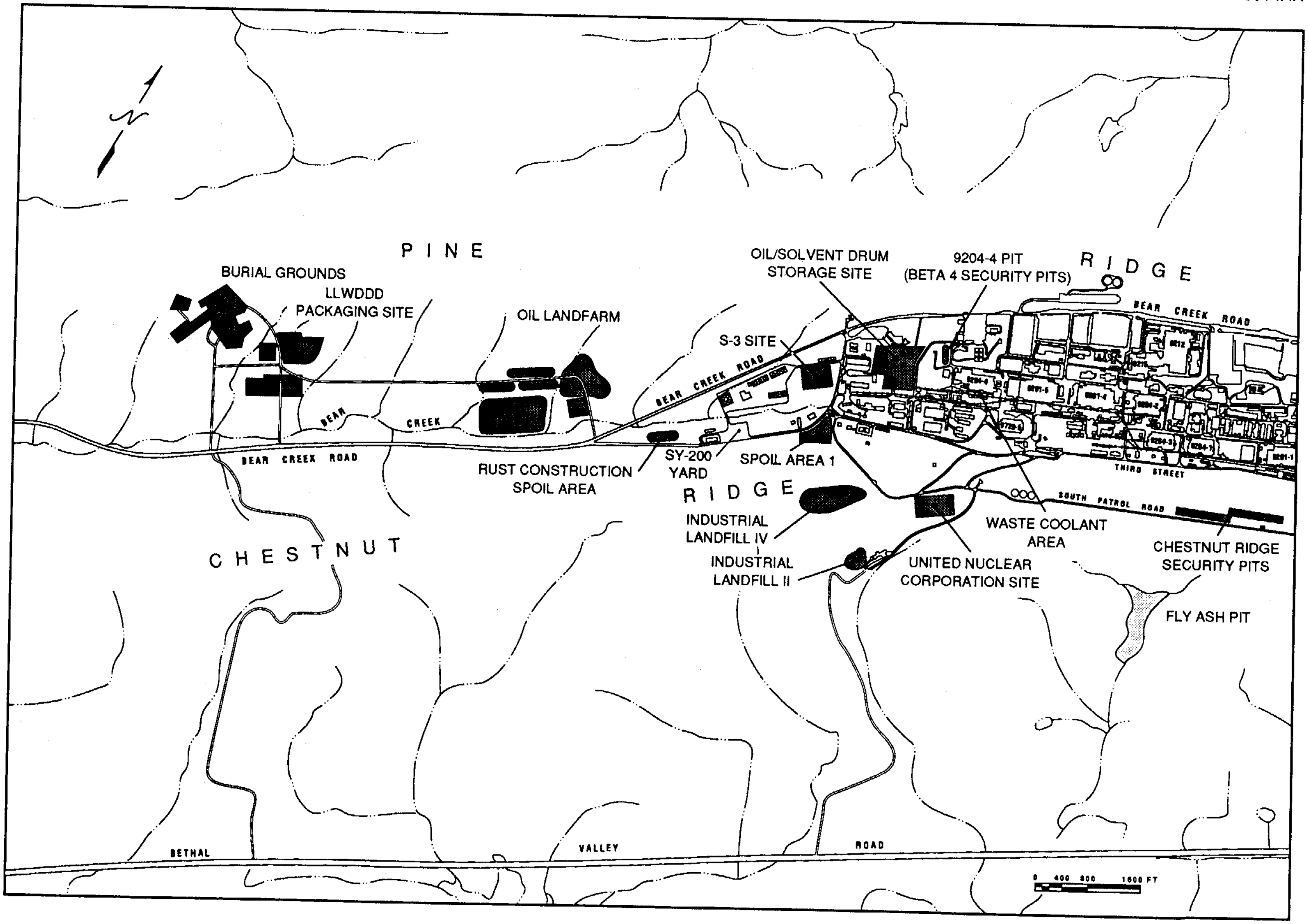

Fig. 4.5. Index maps of Y-12 Plant comprehensive groundwater characterization program by sites (part 2).

into a floor drain that was also connected to Tanks 2328-U and 2329-U.

Located adjacent to each other, Tanks 2328-U and 2329-U were separated by a rubber baffle. Each tank was about 8 ft long, 4 ft wide, 4 ft deep, and had a total capacity of about 950 gal. The tops of the tanks were open at the ground surface. Consequently, rainwater and surface runoff would occasionally collect in the tanks. The baffle between the tanks helped to separate the oils and solvents from the rainwater and runoff. Once separated, the water was released through a drainpipe to the Y-12 Plant stormwater drainage system. The remaining oils and solvents were periodically pumped out as necessary and treated or disposed of in the Bear Creek Burial Grounds.

Leak tests were performed in Tanks 2063-U, 2328-U, and 2329-U in March 1989. Leak rates for each tank were determined at 0.46 gal/h, 0.14 gal/h, and 0.14 gal/h, respectively. Each of these results exceeded the maximum allowable leak rate established under federal UST regulations and the tanks were subsequently excavated. Elevated concentrations of cadmium, lead, and mercury, as well as detectable levels of volatile organics, and PCBs were detected in soil samples collected in the vicinity of the tanks.

Interim Drum Yard

The Interim Drum Yard is located in the southwestern portion of the UEFPCHR about 1300 ft east of the S-3 Site. The site is currently a graveled, covered, and diked outdoor storage area used to store drums containing various hazardous, mixed, and nonhazardous wastes including chromium-containing sludge, mercury-contaminated wastes, chlorinated and nonchlorinated organics, and plating solutions. Materials contaminated with PCBs are not presently stored at the site but have been in past years. Approximately 900 drums, all stored in temporary buildings with diking, are currently stored at the site. The southern portion of the yard has been closed as required under an approved RCRA closure plan.

S-2 Site

The S-2 Site is located in the southwestern portion of the UEFPCHR on the southern edge of the Y-12 Plant complex (Fig. 4.4). The site was used from 1943 to 1951 to dispose of an unknown quantity of liquid wastes. Waste materials reported to have been disposed of include nitrates of copper, nickel, and chromium; diethyl ether and pentaethers; nitric, hydrochloric, and sulfuric acids; sulfates; dibutyl carbitol and tributyl phosphates; aluminum nitrate; hydrogen fluoride; cadmium; natural and enriched uranium; and cyanide compounds. The site consisted of an unlined earthen reservoir into which the liquid waste streams were emptied for percolation, evaporation, or neutralization. The site was closed in 1951, the remaining liquids were neutralized, and the reservoir was filled with soil and seeded with grass.

Mercury Process Spill Areas

The Mercury Process Spill Areas (Fig. 4.4) were classified under DOE CERCLA (order 5480. 14) for the Y-12 Plant but are now considered SWMUs regulated under RCRA; an RFI Plan for these sites was submitted to EPA in December 1989. Mercury was used in the COLEX process for the extraction of lithium isotopes at the Y-12 Plant between 1955 and 1962. Shipments of clean mercury were transported to the plant in flasks. Mercury was taken from the flasks and inserted into the process lines at the deflasking areas. The potential for spills or leaks of mercury existed at these sites.

Abandoned nitric acid pipeline

The Abandoned Nitric Acid Pipeline is located in the northwestern portion of UEFPCHR within the Y-12 Plant compound. A small portion of the pipeline extends into the BCHR. The pipeline was completed in 1951 and used to transport effluent derived from operations in Buildings 9212 and 9206 to the S-3 Ponds. Subsequently, the line was connected to the uranium recovery process lines from the H-1 Foundry (Building 9998). The effluent generally consisted of nitric acid with uranium in solution. It is estimated that during its operation, up to 5500 gal/d of effluent was pumped through the pipeline to the S-3 Ponds. Use of the pipeline ceased in 1983. Available construction drawings of the abandoned Nitric Acid Pipeline indicate that is was constructed of 1.5- to 3-in.-diam 347 stainless steel pipe. Some sources indicate that a section of the pipeline may have been constructed of 6-in.-diam stainless steel, but this has not been substantiated by existing design or construction drawings. The pipeline was originally buried up to 14 ft below ground level and was encased in concrete where it passed over water or sewer lines. These concrete casements extended up to 10 ft on either side of the overlain water or sewer line; no such lines are shown on available drawings as being buried above the pipeline. According to drawings generated during the construction of the Y-12 Plant Perimeter Intrusion Detection and Alarm System (PIDAS) security system, sections of the pipeline may have been abandoned and rerouted during its operational period. Specific information and reasons for this rerouting are not available.

Beta-4 Security Pits

The Beta-4 Security Pits are located near the northwestern edge of the UEFPCHR (Fig. 4.5). The site was operated from 1968 to 1972 and was used for the disposal of uranium and uranium alloys, metals containing depleted and enriched uranium, organic compounds, acids, and miscellaneous debris.

Waste Coolant Processing Area

The Waste Coolant Processing Area is located in the east-central portion of the Y-12 Plant (Fig. 4.4) and has been used to treat waste coolants collected from various shops within the plant complex. The site originally consisted of the Waste Machine Coolant Biodegradation Facility (WMCBF), an unloading/storage area, and a treatment basin/effluent drain field. Operation of the WMCBF was discontinued in 1985 when it was replaced with a new treatment unit, the Waste Coolant Processing Facility (WCPF). The original unloading/storage area was retained as part of the WCPF, but the WMCBF and the treatment basin/effluent drain field were closed in accordance with an RCRA closure plan; final closure was certified by the TDC on November 23, 1988. The WCPF is fully contained within concrete dikes, and releases of waste coolants from the facility are unlikely. However, releases associated with past operations at the WMCBF are clearly indicated by groundwater quality data obtained from monitor wells at the site.

Coal Pile Trench

The Oak Ridge Y-12 Plant disposed of uranium and nonuranium materials in 1965 and 1966 by burying them in the Coal Pile Trench located beneath the present coal pile at the Steam Plant. The Coal Pile Trench was constructed in the summer of 1965 and consists of a trench 161 ft long, 14.5 ft wide, and 15 ft deep. The trench received material from August 9, 1965, through September 1965 and from July 11, 1965, through September 29, 1966. Approximately 1,750,000 kg (1,930 tons) of depleted uranium and depleted uranium alloys are reported to have been buried over this time. Also, the trench contains at least 318 kg (0.35 tons) of carbon products, 147 kg (0.16 tons) of molybdenum, 576.9 kg (0.64 tons) of thorium, and 78,713 kg (87 tons) of other nonuranium materials.

Four groundwater monitoring wells were installed in 1984. Analysis of the groundwater quality data revealed only one well with elevated uranium concentrations. Sulfate, electrical conductance, and pH data indicated that groundwater was contaminated by the coal pile.

Five shallow and three deep wells were installed in the fall of 1990 to further investigate groundwater contamination. Low levels of uranium were found in upgradient groundwater samples at 3.03 μg/L and in one downgradient well at 4.72 μg/L. Beryllium, nickel, lead, cadmium, chromium, and arsenic were detected in levels above maximum contaminated levels (MCLs) in shallow monitoring wells. Uranium levels within the deep wells were within background values. Sulfate levels were elevated above proposed MCLs of 400 mg/L in all deep wells. Molybdenum was not found in any downgradient wells. These data further indicate that the coal pile is a major contributor to groundwater contamination in this area.

Building 81-10

The Building 81-10 area is located south of the UEFPC and is adjacent to the PIDAS security system. The building was originally built as a tin shed, but in the late 1950s and early 1960s it housed a roasting furnace that was used for recovery of mercury from sludges, wastes, contaminated soils, and other scrap materials. During operation, an estimated 3000 lb of mercury was spilled on the building's concrete foundation, beneath it, and on the ground. Building 81-10 and its sumps were cleaned in 1971.

Soil and groundwater sampling of the Building 81-10 area was conducted in the fall of 1990. Seven groundwater wells were installed at depths between

16 and 75 ft. Surface soil samples were found to contain heavy metals, particularly mercury. Mercury concentrations were highest in the upper 8 ft of soil. Total metal concentrations of beryllium, chromium, lead, nickel, and mercury were detected above MCLs in groundwater. Mercury was detected in only one groundwater well. Tetrachloroethene, trichloroethene, carbon tetrachloride, 1,2 dichloroethene, and vinyl chloride were detected above MCLs in two groundwater wells.

Garage underground tanks (formerly 9754 Fuel Facility)

The 9754 Fuel Facility was used from 1945 until it was closed in 1978. Originally it consisted of two 10,000-gal diesel fuel and leaded gasoline tanks. A 20,000-gal unleaded gasoline tank was installed at the site in 1975. These three tanks, currently known as the garage underground tanks (GUTs), were used to gravity-feed three 1000-gal tanks located at a dispenser island in front of former Building 9754 (Fig. 4.4) and two diesel fuel and gasoline emergency dispensers located west of the building. Product releases from overfilling of the gravity-feed system have occurred. Beginning in 1978, use of the GUTs was changed from fuel storage to waste oil storage. These tanks were subsequently removed, and the tank site is currently undergoing RCRA closure. Also in 1978, the three 1000-gal dispenser tanks were emptied, the emergency dispensers were removed, and Building 9754 was demolished. These dispenser tanks are being closed under UST regulations in conjunction with closure of the 9754-2 Fuel Facility.

Gasoline and diesel fuel spills and leaks at the site have been documented. Spills typically occurred when the tanks were overfilled. Gasoline leaks from Tank 0439-U fill pipe and discharge line were confirmed during leak testing and subsequent tank excavation. During excavation of Tank 0440-U, it was noted that leaks from an associated discharge line had occurred.

In June 1989, free product was observed in the collection basin connected to the tank pit. A sump was subsequently excavated adjacent to the tank pit to facilitate free product recovery and removal of contaminated groundwater. Free product and contaminated water were regularly pumped from the sump for several weeks. A recovery well was then installed downgradient of the tank pit, but no free product was observed in the well.

Underground storage tanks

9754-2 Fuel Facility

The 9754-2 Fuel Facility is located in the eastern portion of the UEFPCHR near the east boundary of the Y-12 Plant (Fig. 4.4). When in operation, the facility contained two fiberglass USTs: a 20,000-gal tank (Tank 0439-U) containing unleaded gasoline and a 10,000-gal tank (Tank 0440-U) containing diesel fuel. Both tanks were located in an unlined gravel-filled pit about 12 ft in depth. The top of the tank pit was not covered. Surface water runoff entering the tank pit was drained through a 12-in.-diam concrete pipe to a nearby collection basin.

Tank 2331-U

Tank 2331-U is a 560-gal steel tank used to store gasoline. The tank and its associated piping were installed in 1973 to serve gasoline-powered equipment in Building 9201-1 (Fig. 4.4). A leak test performed in September 1988 indicated that the tank was leaking at a rate of about 0.5 gal/h. Further use of the tank was subsequently discontinued, and the tank was removed in December 1988. Results of a preliminary investigation at the site indicated that hydrocarbons (toluene and xylene) were present at detectable levels in soils near the tank pit. A monitor well was installed downgradient of the tank pit to facilitate detection and recovery of any free product. Petroleum odors in the well were noted; however, no free product was observed.

Tank 0134-U

Tank 0134-U, a steel tank with a capacity of 117 gal, was used to store gasoline for emergency electrical power generation at Building 9204-2. The tank was installed in the mid-1960s and was removed from service in 1982. When it was removed, several holes were observed in the sides of the tank. Since removal of the tank, a concrete slab has been poured on the bottom of the tank pit, and a new tank has been installed. Follow-up investigations at the site indicated that volatile organics were present in soils and groundwater in the area. A monitor well was subsequently installed downgradient of the site to facilitate detection and recovery of any free product. No free product was observed, but petroleum odors in

Table 4.5. Waste sites included in the 1990 Assessment Program for BCHR

Site	Regulatory classification[a]
S-3 Waste-Management Area[b]	
S-3 Site	RCRA T/S/D Unit
Oil Landfarm Waste-Management Area	
Oil Landfarm HWDU	RCRA/T/S/D Unit
Burnyard/Boneyard	SWMU
Chemical Storage Area	SWMU
Sanitary Landfill I	SWMU
Bear Creek Burial Grounds Waste-Management Area	
Burial Grounds A and C	RCRA T/S/D Unit
Burial Grounds B, D, E, and J	SWDU
Oil Retention Ponds Nos.1 and 2	SWMU
Abandoned Nitric Acid Pipeline	SWMU
SY-200 Yard	SWMU
Rust Spoil Area	SWMU
Spoil Area I	SWMU
LLWDDD Sites	*c*

[a]RCRA T/S/D Unit = RCRA regulated land-based treatment, storage, or disposal unit. SWMU = Solid Waste Management Unit. SWDU = Solid Waste Disposal Unit (nonhazardous waste).

[b]The S-3 Waste Management Area sits atop the groundwater flow divide separating the Bear Creek and Upper East Fork Poplar Creek hydrogeologic regimes.

[c]Not applicable.

the well were noted. Additional wells were installed in 1990 as part of a UST site investigation.

Bear Creek Hydrogeologic Regime (BCHR)

Three categories of sites are located within the BCHR: (1) RCRA interim status T/S/D sites, (2) individual RCRA interim status T/S/D units within WMAs that include one or more SWMUs, and (3) individual SWMUs that are not located within the WMA of any T/S/D unit. The waste sites located within the BCHR are listed in Table 4.5.

Three WMAs located in the BCHR comprise what has been historically referred to as the Bear Creek Valley Waste Disposal Area (BCVWDA). These include the S-3 Site WMA, the Oil Landfarm WMA, and the Bear Creek Burial Grounds WMA (Fig. 4.5). The BCVWDA was used until the early 1980s as the primary area for the disposal of various types of hazardous and nonhazardous wastes that were generated at the Y-12 Plant as part of production processes.

In addition to the three WMAs comprising the BCVWDA, four SWMUs are also located within the BCHR: a portion of the Abandoned Nitric Acid Pipeline, the SY-200 Yard, Spoil Area I, and the Rust Spoil Area. These sites were identified to comply with RCRA regulations governing implementation of the Hazardous and Solid Waste Amendments (HSWA) enacted by Congress in November 1984. These sites will be evaluated by site-specific RCRA Facility Investigations.

Two low-level waste disposal and demonstration (LLWDDD) projects have groundwater monitoring wells installed to collect hydrogeologic characterization information and background groundwater chemistry data. These wells were incorporated into the Y-12 Plant monitoring well network for the BCHR in 1990.

RCRA T/S/D units

S-3 Site

The S-3 WMA originally consisted of only the S-3 Site when assessment monitoring was initiated. This was expanded in 1988 to encompass the SWMUs and process spill areas, because assessment data had indicated that groundwater contaminant plumes originating from many of these sites had intermingled with the plumes originating from the S-3 Site. However, only the S-3 Site lies within the *BCHR*; the remaining SWMUs and process spill areas lie across the groundwater flow divide that separates the BCHR and the UEFPCHR. Descriptions of these SWMUs and process spill areas are provided in the UEFPCHR waste site descriptions. The S-3 Site was constructed in 1951 and consisted of four unlined surface impoundments covering an area of roughly 400 by 400 ft. The original pond excavations penetrated residual soil and fill materials but did not extend down to bedrock. While in operation each pond had a storage capacity of about 2.5 million gal. Disposal of hazardous waste at the S-3 Ponds was discontinued in 1984.

In 1988, the S-3 Ponds were closed as a landfill in accordance with the requirements of TDC Rule 1200-1-11-.05(14)(e). When closed, the ponds contained 2 to 5 ft of sludge produced by the in situ denitrification and neutralization of wastewater in the ponds. The sludges were determined to be nonleachable in weak acid and groundwater. In addition, a small volume of contaminated sediments was removed from Bear Creek and deposited in the ponds prior to capping. As required under the TDC-approved closure plan, the sludge and sediments were stabilized with coarse aggregate and covered with a five-part engineered cap of low-permeability material. An asphalt parking lot has been constructed over the cap to complete closure of the site. Final closure of the site was certified by the TDC on November 15, 1990.

Oil Landfarm HWDU

The Oil Landfarm WMA is located on the southern slope of Pine Ridge approximately 1 mile west of the Y-12 Plant and is made up of one land-based RCRA T/S/D facility, the Oil Landfarm Hazardous Waste Disposal Unit (HWDU), and four SWMUs (the Boneyard, the Burnyard, Sanitary Landfill I, and the Chemical Storage Area).

The Oil Landfarm HWDU was used for the application of waste oils and coolants to nutrient-adjusted soil during the dry months of the year (i.e., April to October) to encourage biodegradation. These oils and coolants were known to contain beryllium compounds, depleted uranium, PCBs, tetrachloroethene, and 1,1,1-trichloromethane. Disposal of the oils and coolants at the Oil Landfarm HWDU was discontinued in 1982. Final closure of the site was certified by TDC on December 15, 1990.

Bear Creek Burial Grounds A and C

The Bear Creek Burial Grounds WMA is located on the southern slope flank of Pine Ridge approximately 2 miles west of the Y-12 Plant (Fig. 4.5) and is made up of several waste disposal units designated as Burial Grounds A, B, C, D, E, and J. Of these, only Burial Grounds A and C have been designated RCRA HWDUs. Each disposal unit consisted of a series of trenches excavated to depths of 14 to 25 ft below grade. Perforated standpipes installed vertically in some trenches were used for liquid waste disposal. Rock and gravel were backfilled around the standpipes for support and to maximize the rate of drainage. Other trenches received only solid wastes. Although some portions of the Burial Grounds WMA are currently used for disposal of nonhazardous solid wastes, all hazardous waste disposal activities were discontinued in 1981. The disposal trenches are currently being closed as RCRA units. Burial Ground A was certified closed by the TDC on December 15, 1989; certification of final closure of Burial Ground C was requested from TDC on December 27, 1990.

Solid waste management units

Boneyard, Burnyard, and Chemical Storage Area

The Oil Landfarm WMA is located on the southern slope of Pine Ridge approximately 1 mile west of the Y-12 Plant and is made up of one land-based RCRA T/S/D facility, the Oil Landfarm HWDU, and four SWMUs (i.e., the Boneyard, the Burnyard, Sanitary Landfill I, and the Chemical Storage Area).

The Boneyard, Burnyard, and Chemical Storage Area are located east of the Oil Landfarm HWDU. Although these were individual waste disposal sites at various times between 1943 and 1981, they have been grouped as a single unit. The Boneyard was used for the disposal of magnesium chips, which were placed in earthen trenches and burned, and for the disposal of inert construction spill material such as concrete and steel rebar. Various types of refuse (including pesticide containers, metal shavings, solvents, oils, and laboratory chemicals) were placed in unlined earthen trenches at the Burnyard and incinerated between 1943 and 1968; residues were then transported to the Boneyard and buried. The southeast corner of the Boneyard/Burnyard was closed in 1989 when an engineered cap was installed. The remainder of the area is expected to be regulated as a CERCLA site.

Sanitary Landfill I

Sanitary Landfill I received various types of nonhazardous waste from the Y-12 Plant. Waste disposal at Sanitary Landfill I was terminated in 1982, and the site was graded, capped, and closed in 1983.

Oil Retention Ponds 1 and 2

In addition to the disposal trenches, the Burial Ground WMA also included two ponds: Oil Retention Ponds 1 and 2. The ponds were constructed adjacent to Burial Ground A to collect seepage from the trenches. Final closure of the ponds was certified by the TDC on November 15, 1990, and December 11, 1990, respectively.

Abandoned nitric acid pipeline

Only a relatively small section of the Abandoned Nitric Acid Pipeline lies within the BCHR; most of the pipeline is located within the Y-12 Plant compound. A complete description of the pipeline is given in the UEFPCHR section.

SY-200 Yard

The SY-200 Yard is located south of Bear Creek near the base of the northern slope of Chestnut Ridge, approximately 0.4 miles west of the Y-12 Plant. Operated from the 1950s to 1986, the SY-200 Yard was an outside graveled area of about 300 by 200 ft that was used for aboveground temporary storage of equipment, machinery, and miscellaneous items. Records indicate that the site was not used for storage or disposal of waste materials; tanks and container materials stored at the site were empty. Items stored at the site were removed by September 1986 to prepare the area for proposed new construction. On breaking ground for the proposed new construction, visible mercury and asbestos debris were discovered.

Spoil Area I

Spoil Area I is located on the northern slope of Chestnut Ridge, west of the Y-12 Plant near the intersection of Old Bear Creek Road and West Patrol Road. The 5-acre site has been in operation since about 1980 as a disposal area for nonhazardous, nonradioactive construction debris. In 1985 the TDC issued a permit allowing the site to be used as a landfill for rubble and noncombustible, nonputrescible solid waste. About 100,000 yd^3 of nonuranium contaminated construction debris has been disposed at the site.

Rust Spoil Area

The Rust Spoil Area is located adjacent to the SY-200 Yard. The 5.4-acre site had been used primarily by Rust Engineering for the disposal of solid waste (i.e., spoil material) generated during various renovation, maintenance, and construction operations at the Y-12 Plant. Utilized from 1975 to 1983, no more than 100,000 yd^3 of nonuranium contaminated construction debris and spoil is estimated to have been disposed of at the site. Although no detailed disposal records are available, the bulk of the waste disposed at the Rust Spoil Area consisted of soil, masonry, metal such as steel, and rebar in concrete. Minor amounts of solvent-contaminated material containing asbestos, mercury, and uranium may have been disposed in this area. The existing administrative and other controls prevented disposal of significant amounts of chemicals or contaminated materials. Closure of the site was completed in 1984 in accordance with a TDC-approved closure plan.

Other Sites

LLWDDD

The above-grade demonstration, an LLWDDD project, was planned for a site in the Bear Creek Burial Grounds approximately 2.5 km (1.6 miles) west of the Y-12 Plant. In preparation for this facility, four groundwater wells were installed to enable better understanding of the hydrology of the area and to acquire baseline characterization data. Background data were collected at this site, and values above standards have been detected. Although these values may be indicative of groundwater contamination, the values are background for this LLWDDD site, and the sources of contamination are upgradient within the BCBG WMA. Construction of this facility has been halted, and no additional construction has occurred beyond the initial site preparation phase.

The Y-12 Plant generates solid wastes contaminated with low levels (i.e., less than 1% by weight) of ^{238}U. Permitted burial grounds for these wastes may be filled as early as 1992. Permits for new burial grounds will require verification that human health and the environment will be adequately protected. The uranium lysimeter demonstration project was proposed to generate the data required to verify that uranium-contaminated wastes from the Y-12 Plant can be adequately managed using shallow-land burial.

In 1989 five wells were installed to monitor background hydrogeological conditions at the site. The wells were sampled in 1990 as part of the BCHR groundwater quality assessment.

Chestnut Ridge Hydrogeologic Regime (CRHR)

Three categories of sites are located within the CRHR: (1) RCRA interim status units, (2) individual SWMUs and solid waste disposal units, and (3) TDC-permitted solid waste disposal facilities. The waste sites located within the CRHR are listed in Table 4.6. Of the waste disposal sites located in the CRHR, only the Security Pits have been confirmed as a source for groundwater contamination.

RCRA T/S/D units

Chestnut Ridge Security Pits

The Chestnut Ridge Security Pits HWDU is located on the crest of Chestnut Ridge, southeast of the central portion of the Y-12 Plant. Operated since 1973, the site consists of a series of trenches that were used for the disposal of classified hazardous and nonhazardous wastes. Disposal of hazardous waste materials was discontinued in December 1984 and nonhazardous waste on November 8, 1988.

The trenches at the Chestnut Ridge Security Pits are located in two adjacent areas (Fig. 4.5) and are about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Typically, several trenches were opened simultaneously to allow for the segregation of wastes in separate cells. After a trench was filled, it was covered with 6 to 12 in. of soil. Six auger holes, each about 2 ft in diameter and 10 ft deep, are located just east of the eastern trench and were used for the disposal of particularly reactive materials.

An estimated 3950 tons of waste materials was disposed at Chestnut Ridge Security Pits HWDU. However, because of the sensitive nature of the types of wastes disposed at the site, detailed waste inventories are classified. Ten major categories of wastes are identified in an unclassified inventory including acids, fiberglass, beryllium, biological material, debris, heavy metals, inorganics, organics, thorium, and uranium . The site was closed in 1988 in accordance with a TDC-approved closure plan. Closure consisted of placing a low-permeability, low-maintenance cover over the trenches. The site was certified closed by TDC on December 15, 1989.

The chemical characteristics of groundwater beneath the Chestnut Ridge Security Pits HWDU have not changed significantly in comparison with the assessment results obtained in previous years. The most prevalent VOCs remain 1,1,1-trichloroethane, tetrachloroethene, 1,1-dichloroethane, and 1,1-dichloroethene. Two distinct populations of VOCs are still discernible: one is dominated by 1,1,1-trichloroethane; the other, by tetrachloroethene.

Table 4.6. Waste sites included in the 1990 Assessment Program for CRHR

Site	Regulatory classification[a]
Chestnut Ridge Security Pits	RCRA T/S/D Unit
Chestnut Ridge Sediment Disposal Basin	RCRA T/S/D Unit
Kerr Hollow Quarry	RCRA T/S/D Unit
East Chestnut Ridge Waste Pile	RCRA T/S/D Unit
Filled Coal Ash Pond	SWMU
UNC Site	SWMU
Rogers Quarry	SWMU
Sanitary Landfill II	Permitted SWDU
Industrial Landfill III	SWDU
Industrial Landfill IV	Permitted SWDU

[a]RCRA T/S/D Unit = RCRA regulated land-based treatment, storage, or disposal unit. SWMU = Solid Waste Management Unit. SWDU = Solid Waste Disposal Unit (nonhazardous waste).

Samples from newly installed perimeter wells (i.e., GW-607, GW-608, GW-610, and GW-611) generally contained low to nondetectable levels of VOCs. An exception was well GW-609 (open from 256 to 269 ft below ground surface); it contained VOCs at levels that would indicate some downward migration underneath adjacent shallower wells. Relatively high total VOC concentrations at GW-612 also indicate that the vertical extent of the plume in the vicinity of the Security Pits has not been defined and may indicate the presence of dense nonaqueous-phase liquids at depth.

Average activities for gross alpha and gross beta activity were below their respective standards of 15 pCi/L and 50 pCi/L. However, GW-174 had one occurrence in the first quarter in which beta activity exceeded 50 pCi/L. Well GW-180, which had showed an increasing trend in beta activity, had a maximum reported activity of 5.81 ± 3.10 pCi/L in 1990. Continued monitoring for gross alpha and beta activity does not appear to be necessary.

During 1990, a dye tracer study was initiated at the Security Pits to identify natural discharge points for groundwater draining from that portion of Chestnut Ridge. These discharge points will be identified as those sites where dye was positively identified by fluorometric analysis of activated charcoal detectors. A field study was conducted to locate all possible discharge points in all directions surrounding the Security Pits. The sites were monitored for background contributions of fluorescein for 2 weeks prior to start of test. Well GW-178 was selected as a suitable place to insert the dye because it is screened in bedrock, in which case the dye would bypass the residual soil and shorten the test.

Fluorescein was chosen for this initial tracer test because it is typically the most successful for semiquantitative, initial tests. Ten kilograms (~20 lbs) of dry Fluorescein powder was mixed with potable water and inserted into a well following a primer of 1000 gal of potable water. An additional 1000 gal of potable water was pumped into the well as a chaser. The primer and chaser technique is considered essential when no direct recharge point into the aquifer is available. The dye was inserted on July 11, 1990.

A preliminary report of results was issued in December 1990. Fluorescein dye, placed into the groundwater through monitoring well GW-178, was positively recovered from activated charcoal samplers at five different conduit-type springs, one monitoring well, and six surface water sites.

A surface water site near the intersection of Bethel Valley Road and Scarboro Road where dye was possibly recovered at the highest concentration also had the highest measured background value reported. This site lies downstream from the site of an old landfill at the junction of Highway 62 and Union Valley Road. Background measurements of the actual dye often occur in streams, springs, and other such bodies that are hydraulically connected with a landfill. Thus the possibility that the dye originated at a location other than GW-178 has not been ruled out.

Monitoring will continue during 1991. A second tracer study is proposed to evaluate groundwater flow further in lieu of additional monitoring well installation at the Security Pits.

Chestnut Ridge Sediment Disposal Basin

The CRSDB is located on Chestnut Ridge immediately southeast of far eastern end of the Y-12 Plant. It is approximately 900 ft southeast of New Hope Pond. The CRSDB received sediment and spoils from dredging and cleaning operations conducted in New Hope Pond during the 1970s.

The site has been closed, per an approved TDC closure plan, since 1989. During 1990 the site continued in detection monitoring. No evidence or releases have been found in groundwater at the site.

Kerr Hollow Quarry

Kerr Hollow Quarry is located on a low ridge running along the north side of Bethel Valley. The quarry was active in the 1940s but was abandoned in that same year. From the early 1950s through the late 1980s the quarry was used for the disposal of reactive materials from the Y-12 Plant and ORNL. Disposal of such materials ceased in 1989. The site remains in detection monitoring, and no evidence of contaminant releases to groundwater has been obtained.

East Chestnut Ridge Waste Pile

The East Chestnut Ridge Waste Pile is an interim status RCRA hazardous waste storage facility constructed in FY 1987. Five groundwater wells were installed around this facility to allow monitoring, although the regulations do not require monitoring because this is a lined facility.

Solid waste management units

Filled Coal Ash Pond

A total of six polyvinyl chloride (PVC) piezometers were installed upgradient from the Filled Coal Ash Pond during July and September 1990. During this same period, three shallow and two deep bedrock site characterization wells were installed downgradient from the ash pond. The wells were sampled in October 1990. Cadmium, chromium, and lead were detected at levels slightly in excess of MCLs. Levels of alpha and beta activity were significantly elevated above MCLs in surface water and groundwater samples collected immediately below the Filled Coal Ash Pond.

UNC Site

The UNC Site is located on the northern crest of Chestnut Ridge immediately south of the western end of the Y-12 Plant complex. The site was used to dispose of waste from a UNC plant in Rhode Island. Materials disposed of are nitrate-contaminated, low-level radioactive wastes and contaminated equipment packaged in 208-L (55-gal) drums and in boxes.

Groundwater investigation was initiated at the UNC Site in 1985. Hydrological data indicate that the shallow groundwater system is relatively uncomplicated. Shallow groundwater flow directions are consistently to the northeast. The data also indicate that a downward flow component to the shallow groundwater system occurs throughout the site. Major element data suggest that all of the groundwater at the site is chemically similar and belongs to the same groundwater flow system. The water quality data from 1990 were consistent with the conclusion that the UNC Site is not contributing contamination to the groundwater.

Rogers Quarry

Rogers Quarry is located along Bethel Valley Road approximately 5 km west of Kerr Hollow Quarry and 8 km (5 miles) east of ORNL. The quarry is approximately 910 m (2985 ft) south of the Y-12 Plant complex and is located on a line of low hills running along the north side of Bethel Valley at the southern edge of Chestnut Ridge. The quarry was a source of stone construction materials from the 1940s through the late 1950s. It was abandoned in the early 1960s when it filled with water. It currently receives fly ash slurry from the Y-12 Steam Plant.

Groundwater investigation was initiated at the Rogers Quarry site in 1985. Hydrological data for the Rogers Quarry locality suggest that the shallow groundwater system is complex and seasonally variable. During periods of high precipitation, one well consistently is upgradient. During low precipitation periods, however, any one of several wells or the quarry itself can be considered upgradient within the groundwater system surrounding the site. The data also indicate that, for several of the wells surrounding the quarry, the hydrostatic heads (i.e., gradients) and the trend patterns are influenced by quarry water level fluctuations. Other wells appear to have trend patterns that behave independently of quarry water level fluctuations. The shallow and variable nature of the water table gradient suggests that groundwater flow surrounding the quarry may be sluggish and that the direction of the gradient may vary throughout the year.

Solid waste disposal units

Sanitary Landfill II

The Y-12 Centralized Sanitary Landfill II (also known as Industrial Landfill II) is a TDC-permitted solid waste disposal facility. Groundwater monitoring is performed per a TDC-approved monitoring plan. Trace levels of 1,1,1-trichloroethane and 1,1-dichloroethane have been detected. An RFI plan for the site has been prepared as part of the Y-12 Environmental Restoration Program, and monitoring for volatile organic contamination will continue.

Industrial Landfill III

Industrial Landfill III is located on the east end of Chestnut Ridge. It is designed for the placement of construction debris and soils from mercury-contaminated areas in and around the Y-12 Plant. Landfill III incorporates the existing East Chestnut Ridge mercury-contaminated soil pile, a former borrow area, that received mercury-contaminated material relocated from around the city of Oak Ridge Civic Center. Seven groundwater wells were installed in 1987.

Industrial Landfill IV

Industrial Landfill IV is located on the west end of Chestnut Ridge southeast of the S-3 Ponds. Five groundwater wells were installed in 1987 in preparation for this waste disposal facility. One of these wells was later plugged and abandoned to allow additional construction work, and it was later replaced. Although several parameters were above standards, these are background numbers because the site was not opened to waste disposal activities until 1989.

4.3.1.4 Monitoring wells installed in CY 1990

In CY 1990, 79 groundwater monitoring wells were installed (Table 4.7). The sites are divided into four categories. Category I sites are those requiring additional data to delineate the extent of groundwater contamination. Wells installed in Category II locations are for monitoring potential exit pathways of groundwater contamination. Category III wells were installed as free-product observation wells and potential recovery wells at sites of leaking underground storage tanks. Category IV wells were installed during Phase I RFIs to assess possible groundwater contamination.

4.3.1.5 Summary of groundwater quality conditions at the Y-12 Plant

Groundwater quality at the Y-12 Plant has been impacted by four types of contaminants: nitrate, volatile organic compounds (VOCs), metals, and radionuclides. Of these, nitrate and VOCs are the most pervasive, although data obtained since 1988 suggest that the extent of some radionuclides may also be significant. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of low pH groundwater at the west end of the plant in the vicinity of the S-3 Site.

Additional monitoring wells installed in 1990 have served to define groundwater quality conditions better at the Y-12 Plant. In the BCHR, horizontal plume boundaries have been defined in most areas. Questions regarding the vertical extent of these plumes, however, still remain. In the UEFPCHR, plume boundaries in both horizontal and vertical directions have not been completely defined. The Chestnut Ridge Security Pits (CRSP) is the only known source of groundwater contamination in the Chestnut Ridge Hydrogeologic Regime. Horizontal plume boundaries at the CRSP are generally defined although the vertical extent of contamination has yet to be established.

4.3.1.6 Nitrate

Groundwater with nitrate concentrations (expressed as N) in excess of the 10 mg/L MCL is found in the unconsolidated zone, the shallow (i.e.,

Table 4.7. Summary of groundwater monitoring wells installed during 1990

Site	Category	Wells installed
Bear Creek Hydrogeologic Regime	I	26
Upper East Fork Hydrogeologic Regime	I	4
Chestnut Ridge Hydrogeologic Regime	I	2
Exit Pathway Monitoring	II	5
Underground Tank Investigations		
Tank 0134-U at 9204-2	III	1
Tank 2331-U at 9201-1	III	3
9754/9754-2 Fuel Facility	III	2
RFIs		
Rust Garage (9754-1)	IV	5
Bldg 81-10	IV	7
Coal Pile Trench	IV	8
Filled Coal Ash Pond	IV	4
East Fork Poplar Creek	IV	12

<85 ft below ground surface) bedrock zone, and intermediate-depth (i.e., 85 to 300 ft below ground surface) bedrock zone in the BCHR and UEFPCHR; nitrate is not present at elevated concentrations in groundwater beneath the CRSP. In the BCHR, groundwater containing nitrate in excess of 10 mg/L occurs up to 3200 ft west of the S-3 Site within the unconsolidated zone, and up to 4400 ft west of the S-3 Site within the shallow bedrock zone. Data obtained in 1990 indicate that, in addition to the previously identified nitrate source at the S-3 Site, an additional source of nitrate contamination to groundwater occurs in the unconsolidated and shallow bedrock zones located east of the Burnyard/Boneyard area in the Oil Landfarm. Throughout the area of nitrate contamination, available data indicate that predevelopment drainage features play a role in the distribution of nitrate in groundwater within the unconsolidated and shallow bedrock zones. Although the highest nitrate concentrations occur in the unconsolidated zone (i.e., 13,900 mg/L) and shallow bedrock zone (i.e., 13,100 mg/L), the maximum extent of nitrate contamination in the BCHR occurs at intermediate bedrock depths where nitrate in excess of 10 mg/L occurs in a relatively narrow belt paralleling geologic strike for about 4800 ft west of the S-3 Site.

In the UEFPCHR, nitrate concentrations in excess of the MCL occur in an area extending at least 1800 ft east of the S-3 site within the unconsolidated and shallow bedrock zones. A general lack of well converge, however, precludes determination of the extent of the nitrate contamination at intermediate bedrock depths in the UEFPCHR. The S-3 Site is the primary source of nitrate contamination to groundwater within the UEFPCHR. Available data indicate that leaks in the Abandoned Nitric Acid Pipeline about 700 to 800 ft east of the S-3 Site and the S-2 Site were additional significant sources of nitrate contamination. As in the BCHR, buried preconstruction drainage features near the west end of the Y-12 Plant may play a role in the distribution of nitrate in groundwater in the unconsolidated and shallow bedrock zones.

4.3.1.7 Volatile organic compounds

Along with nitrate, VOCs are pervasive in groundwater at the Y-12 Plant. VOCs have been detected in groundwater in the unconsolidated zone, in shallow- and intermediate-depth bedrock zones beneath waste disposal areas in the BCHR and UEFPCHR, and beneath the CRSP on Chestnut Ridge.

In the BCHR, VOCs have been identified in wells located at the Bear Creek Burial Grounds, Oil Landfarm, Rust Spoil Area, Spoil Area I, S-3 Waste Management Area, and in wells located between these sites. In the UEFPCHR, VOCs are present in groundwater at the Waste Coolant Processing Area, NHP, and in the vicinity of several petroleum underground storage tanks. Typical constituents in the VOC plumes in both hydrogeologic regimes include tetrachloroethene, trichloroethene, 1,2-dichloroethene, 1,1,1-trichloroethane, and 1,1-dichloroethane.

A relatively continuous dissolved VOC plume in the unconsolidated zone in the BCHR extends westward from the S-3 Site about 6000 ft to just west of the Oil Landfarm. A VOC plume of similar extent occurs in the shallow bedrock zone. The present-day configuration of the shallow VOC plumes resulted from the intermingling within the Maynardville Limestone of VOCs released from the S-3 Site and possibly Spoil Area I with downgradient plumes originating from the Oil Landfarm and the Rust Spoil Area. At intermediate bedrock depths, VOCs are present in the Maynardville Limestone south of the S-3 Site and the Oil Landfarm. Additional wells will be needed to determine if these deeper bedrock plumes have also intermingled. The highest summed VOC concentrations are found in wells located adjacent to the S-3 Site and in the vicinity of the Oil Landfarm's northern plots.

To the west of the Oil Landfarm, separate dissolved VOC plumes occur in groundwater underlying the Bear Creek Burial Grounds in the unconsolidated zone and in all three bedrock-depth zones: shallow, intermediate, and deep [91.44 m (>300 ft)]. The plumes in the bedrock (generally confined to low-permeability shales of the Conasauga Group that underlie much of the Burial Grounds) do not appear to extend to the Maynardville Limestone.

Accumulations of dense, nonaqueous-phase liquids (DNAPLs) were discovered at depths of approximately 274 ft below ground surface along the southern border of Burial Ground A-South within the Bear Creek Burial Grounds. Because of the complex behavior of DNAPLs in fractured rocks, direct determination of the extent of their occurrences within the subsurface is rarely feasible. Accumulations of DNAPLs in the subsurface, however, generate dissolved contaminant plumes within groundwater. Detection and characterization of such plumes typically provide the most reliable means of determining the extent of DNAPL contamination at a site. Samples obtained from wells GW-625 and GW-628 provide direct evidence for the occurrence of DNAPLs at depths of at least 270 ft below ground surface at the Bear Creek Burial Grounds. Additionally, groundwater from several intermediate and deep wells have a suite of volatile organic compound contaminants suggesting that these wells intersect dissolved contaminant plumes associated with subsurface DNAPL accumulations that may occur to depths of up to 500 ft.

Summed VOC concentrations underlying the Burial Grounds (among the highest reported at the Y-12 Plant) exceed 10,000 μg/L in the unconsolidated zone adjacent to waste trenches. Groundwater samples from wells containing DNAPLs consist of (1) an upper, aqueous phase containing tetrachloroethene (930 to 2500 mg/L), trichloroethene (70 to 110 mg/L), and polychlorinated biphenyls (2.8 to 11 mg/L); and (2) a lower, oil-like phase containing tetrachloroethene (450,000 to 530,000 mg/L), trichloroethene (11,000 to 19,000 mg/L), and polychlorinated biphenyls(14,000 to 27,000 mg/L).

In the UEFPCHR a continuous dissolved VOC plume extends from the S-3 Site to about 4000 ft to the east. In addition, high-concentration (>1000-μg/L) VOC "pockets" are found east of Spoil Area I, in the vicinity of the S-2 Site, and in the unconsolidated zone underlying the Waste Coolant Processing Area. In the later location, summed VOC concentrations of 18,000 μg/L were obtained during 1990 sampling. Data obtained in 1990 suggest that a previously unknown source of VOCs lies to the west of the S-2 Site just east of Spoil Area I.

The horizontal extent of the VOC plumes in the UEFPCHR have not been established except at NHP where the downgradient extent of the VOC plume in the unconsolidated and shallow bedrock zones extends about 400 ft from the pond. The upgradient, westward extent of the VOC plume is not completely delineated. Moreover, the highest summed VOC concentrations (i.e., 8000 μg/L) at NHP are found in the Maynardville Limestone hydraulically upgradient of the pond; this suggests that VOCs have been transported in the Maynardville Limestone from other source areas in the Y-12 Plant.

In addition to VOC plumes characterized by dissolved chlorinated solvents, dissolved VOCs associated with petroleum products have been identified in the unconsolidated zone within the UEFPCHR at the Rust Garage Area, the 9754-2 Fuel Facility, and underground storage tanks 0134-U and 2331-U. The highest concentrations (i.e., 54,000 μg/L) of summed benzene, ethylbenzene, toluene, and xylene (BETX) are found in the Rust Garage Area. Elsewhere, summed BETX concentrations are generally less than 5000 μg/L.

In the Chestnut Ridge hydrogeologic regime, VOCs have been detected in groundwater at the CRSP. Two distinct plumes of VOCs have been identified at the site: one plume is located in the vicinity of the western trench characterized by a high percentage of 1,1,1-trichlororethane; a second plume, in the vicinity of the eastern trench, is characterized by a high percentage of tetrachloroethene. Summed VOC concentrations in excess of 100 μg/L extend about 900 ft to the southeast. The vertical extent of the VOC plume at the site has not been defined.

The occurrence of trace levels of VOCs has been noted at Landfill II. At other sites within the CRHR the occurrence of VOCs is erratic and exhibits no relationship between well location, depth, and reported concentration.

4.3.1.8 Metals

Barium, cadmium, chromium, lead, and mercury concentrations in groundwater at the Y-12 Plant were in excess of their respective MCLs in 1990. The occurrence of elevated concentrations of these metals is most common in the vicinity of the S-3 Site. Maximum concentrations of these metals were reported at 200 mg/L of barium, 5 mg/L of cadmium, 0.5 mg/L of chromium, 0.2 mg/L of lead, and 0.2 mg/L of mercury, all of which were detected in samples from wells within the S-3 Waste-Management Area. The occurrence of metals above MCLs elsewhere in the BCHR, the UEFPCHR, and on Chestnut Ridge was somewhat erratic with no apparent relationships between well locations, well depths, and reported concentrations.

4.3.1.9 Radionuclides

Determination of the extent of radionuclide contamination in groundwater is based on gross alpha and gross beta activity with respect to community drinking water supply standards of 15 pCi/L gross alpha and 50 pCi/L gross beta, as outlined in 40 CFR Pt. 141.16. The S-3 Site is the primary source of radionuclides contamination in groundwater at the Y-12 Plant. Gross alpha and gross beta concentrations exceeding 15 and 50 pCi/L, respectively, can be found in the unconsolidated and shallow bedrock zones in an area extending about 2000 ft east and west of the S-3 Site. Elsewhere in the BCHR and UEFPCHR, mean annual activities exceeding these drinking water guidelines could generally be attributed to a quarterly sample "high anomaly" where otherwise low activities were reported.

Efforts to identify the primary alpha and beta particle-emitting radionuclides in groundwater at the Y-12 Plant have been in progress since 1988. The primary alpha-emitting radionuclides investigated are total radium, uranium, ^{237}Th, ^{230}Th, ^{232}Th, ^{241}Am, ^{237}Np, and ^{239}Pu. The primary beta-emitting radionuclides investigated are ^{144}Ce, ^{134}Cs, ^{137}Cs, ^{125}I, ^{129}I, protactinium, ^{228}Ra, ^{89}Sr, ^{90}Sr, ^{99}Tc, ^{231}Th, ^{234}Th, ^{106}Ru, ^{95}Zr, and ^{3}H. Analysis and interpretation of these radionuclide data for groundwaters are ongoing. Preliminary results suggest that the alpha-emitting isotopes of radium, ^{237}Np, and to a lesser extent ^{241}Am are the principal contributors to alpha activity measured in groundwaters near the S-3 Site. Uranium is also a likely primary contributor to the alpha activity; however, additional isotopic data are needed to confirm the extent of its contribution. The beta-emitting isotopes ^{99}Tc, strontium, and ^{3}H are believed to be the primary contributors to the beta activity measured in groundwater at the Y-12 Plant. Of these radionuclides ^{99}Tc has the highest activity and is the most widespread; the highest mean ^{99}Tc activities have been reported in samples from wells 500 ft east of the S-3 Site. Although relatively high activities of ^{231}Th and ^{234}Th have been reported in the BCHR, these radionuclides may be present naturally in the groundwater flow system. Additional sampling and analysis are in progress to evaluate this hypothesis.

4.3.2 Oak Ridge National Laboratory

4.3.2.1 Background

The groundwater monitoring program at ORNL consists of a network of wells of two basic types and functions: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes and (2) piezometer wells used to characterize groundwater flow conditions. ORNL has established an Environmental Restoration Program to provide comprehensive management of areas where past and current research, development, and waste management activities may have resulted in residual contamination of facilities or the environment. Because of the large number of remedial action sites at ORNL located close to one another and the proven hydrologic interconnections between many of these units, individual monitoring and assessment was shown to be impractical. Therefore, the concept of waste area groupings (WAGs) was developed to evaluate potential sources of releases to the environment. A WAG is a group of multiple sites that are geographically contiguous and/or occur within hydrologically defined areas. It allows the establishment of a suitably comprehensive groundwater and surface water monitoring system in a far shorter time than that required to deal with every facility, site, and SWMU individually. Some WAGs share common boundaries, but each WAG represents distinct small drainage areas within which similar contaminants may have been introduced. Monitoring data from each WAG will direct further groundwater studies aimed at addressing individual sites or units within a WAG, as well as contaminant plumes that extend beyond the perimeter of a WAG.

At ORNL, 20 WAGs were identified by the RCRA Facilities Assessment. Eleven of these have been identified as potential sources of groundwater contamination. Additionally, there are a few areas where potential remedial action sites are located outside the major waste area groupings. These individual sites are being considered separately (instead of expanding the area of the WAG) where this would cause excessive distances between the site and the nearest monitoring point. Water quality monitoring wells are being established around the perimeter of the WAGs determined to have a potential for the release of contaminants. Table 4.8 lists the 20 WAGs at ORNL and the number of potential remedial action sites within each WAG. Figure 4.6 shows the location of each of the 20 WAGs.

WAG 1 area

WAG 1, the ORNL main plant area, contains about one-half of the remedial action sites identified to date by the ERP (Table 4.8). WAG 1 lies within the Bethel Valley portion of the WOC drainage basin. The boundaries of the basin extend to the southeast and northeast along Chestnut Ridge and Haw Ridge. The WAG boundary extends to the water gap in Haw Ridge. The total area of the basin in Bethel Valley is approximately 2040 acres. The location of WAG 1 is shown in Fig. 4.6. Bedrock beneath the main plant area is limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group.

Most of the WAG 1 sites were used to collect and to store low-level waste (LLW) but also include spill and leak sites identified over the last 40 years. Because of the nature of cleanup and repair, it is not currently possible to determine which spill or leak sites still represent potential sources of release. Many types of SWMUs (tanks, ponds, waste treatment facilities, leak/spill sites, and landfills) listed by EPA in the definition of an SWMU are included in WAG 1. Most of the SWMUs are related to ORNL's solid and liquid radioactive waste management operations. A listing of the type and number of sites within WAG 1 is given in Table 4.9.

WAG 5 area

WAG 5 is located directly south of the ORNL main plant (Fig. 4.6). This WAG contains 25 sites, 13 of which are tanks that were used to store liquid LLW prior to disposal by the hydrofracture process. WAG 5 also includes the surface facilities constructed in support of both the old and new hydrofracture facilities. The largest land areas in WAG 5 are devoted to SWSA 5 and the Transuranic (TRU) Waste Storage Area. The remaining sites are support facilities for ORNL's hydrofracture operations, two LLW leak/spill sites, and an impoundment in SWSA 5 used to dewater sludge from the original PWTP (3518). At present, LLW tanks at the new hydrofracture facility are being used to store evaporator concentrates pending a decision regarding ultimate disposal of these wastes.

SWSA 5 was used to dispose of solid LLW generated at ORNL from 1959 to 1973. During the period 1959 to 1963, the burial ground served as the Southeastern Regional Burial Ground for the AEC. At the time SWSA 5 burial operations were initiated, a portion of the site, approximately 4 ha (10 acres), was set aside for the retrievable storage of TRU wastes.

The WAG 5 boundary includes the old and new hydrofracture installations. Because Melton Branch flows between the old and new hydrofracture facilities, the New Hydrofracture Facility has a separate boundary.

Table 4.8. Summary of ORNL waste area groupings, 1990

WAG	Description	Number of sites
1	Main plant area	99
2	White Oak Creek/White Oak Lake	2
3	SWSA 3	3
4	SWSA 4	3
5	SWSA 5	25
6	SWSA 6	3
7	LLW pits and trenches area	15
8	Melton Valley area	20
9	Homogeneous reactor experiment (HRE) area	6
10	Hydrofracture injection wells and grout sheets	4[a]
11	White Wing scrapyard	1
12	Closed contractors' landfill	1
13	Environmental research areas	2
14	Tower Shielding Facility (TSF)	2
15	ORNL facilities at Y-12 Plant	5
16	Health Physics Research Reactor area	5
17	ORNL services area	10
18	Consolidated fuel reprocessing area	9
19	Hazardous waste treatment and storage facility	7
20	Oak Ridge land farm	1
	Total	223
	Additional Sites	
b	Surplus-contaminated facilities	29

[a]Principal sites located underground beneath WAG 5.
[b]Not applicable.

WAG 6 area

WAG 6 consists of three SWMUs: (1) SWSA 6, (2) the emergency waste basin, and (3) the explosives detonation trench. The location of WAG 6 is shown in Fig. 4.6. SWSA 6 is located in Melton Valley, northwest of White Oak Lake and southeast of Lagoon Road and Haw Ridge. The site is approximately 2 km (1.2 miles) south of the main ORNL complex. Geologically, WAG 6 is within the White Oak Mountain thrust block and is underlain by strata of the Middle to Late Cambrian Conasauga Group. Waste burials at the 68-acre site were initiated in 1973 when SWSA 5 was closed. A variety of radioactive and hazardous wastes were buried in trenches and auger holes. The emergency waste basin was constructed in 1961 to provide storage of wastes that could not be released from ORNL to WOC. The basin is located northwest of SWSA 6 and has a capacity of 15 million gal. To date, the basin has not been used. Radiological sampling of the small drainage from the basin has shown the presence of some radioactivity. The source of this contamination is not known.

WAG 7 area

WAG 7 is located in Melton Valley about 1.6 km (1 mile) south of the ORNL main plant area (Fig. 4.6). In terms of radioactivity, the major sites in WAG 7 are the seven pits and trenches used from 1951 to 1966 for the disposal of liquid LLW. WAG 7 also includes a decontamination facility, three leak sites, a storage area containing shielded transfer tanks and other equipment, and seven fuel wells used to dispose acid solutions containing enriched uranium (primarily) from HRE fuel.

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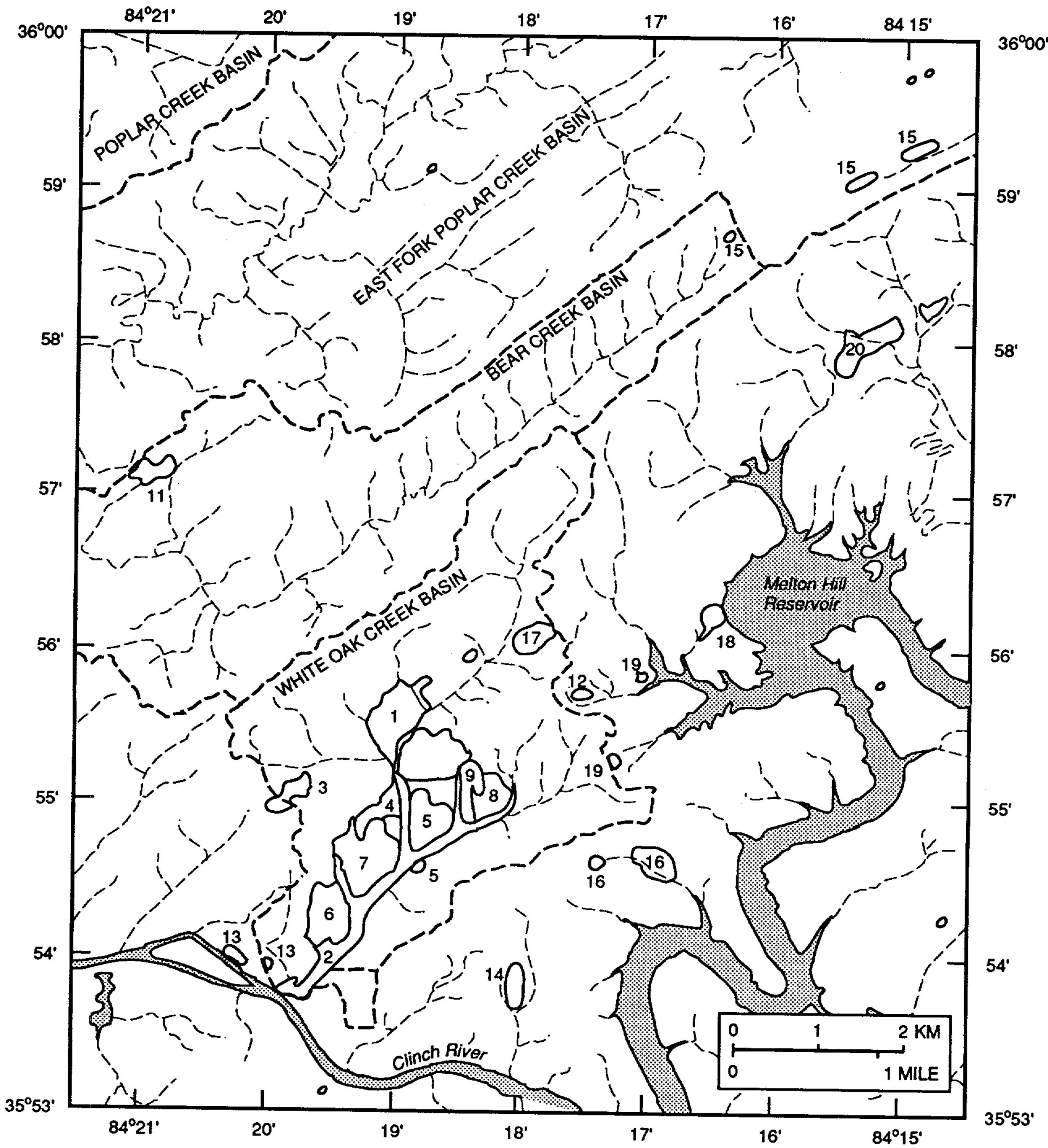

Fig. 4.6. ORNL WAGs.

Table 4.9. Listing of WAG 1 sites by type, 1990

Type of site	Number of sites
Collection and storage tanks (LLW)	
Inactive	22
Active	24
Leak/spill sites and contaminated soils	
Radioactive	30
Chemical	4
Ponds and impoundments	
Radioactive	6
Chemical	3
Waste treatment facilities	
Radioactive	2
Chemical and sewage waste	2
Solid waste storage areas	
Radioactive	3
Chemical and sewage waste	1
Miscellaneous facilities	
Chemical and sewage waste	2
Total	99

4.3.2.2 ORNL 1990 groundwater quality well installation, development, and sampling activities

Groundwater quality monitoring wells for the WAGs are designated as upgradient or downgradient (perimeter) depending on their location relative to the general direction of groundwater flow. Upgradient wells are located to provide groundwater samples that are not expected to be affected by possible leakage from the site. Downgradient wells are positioned along the perimeter of the site to detect possible groundwater contaminant migration from the site. All 173 perimeter monitoring wells have been installed for the WAGs. As remedial investigations proceed, characterization wells are installed inside the WAG perimeters to investigate contaminant transport.

SWSA 6 is the only currently operating disposal area for low-level radioactive waste at ORNL. Interim-status assessment monitoring of groundwater under RCRA regulations was conducted semiannually for CY 1990. The remaining WAGs are currently remedial action sites regulated under RCRA 3004(u), which does not specify sampling schedules. ORNL has plans to sample groundwater quality monitoring (GQM) wells at the remaining WAGs on a semiannual schedule.

In December 1989, a groundwater assessment plan (GWQAP) was submitted through DOE for transmission to TDC and EPA. The plan describes the general field investigation approach for assessment monitoring and the detailed sampling and analysis plan to be used in defining the horizontal and vertical extent of the contaminant plume, characterization of contaminants, and rates and directions of movement. The first annual *Groundwater Quality Assessment Report for SWSA 6 for 1990* was submitted to TDC in March 1991. The report recommended a revised sampling strategy based on results of the analyses.

4.3.2.3 ORNL groundwater results

WAG 1 results

The 27 perimeter wells at WAG 1 were sampled once during September and October for 1990. Data are summarized in Table 4.13 of Vol. 2. Well number 817 was dry; therefore no data are provided. Wells in WAG 1 have now been sampled a total of five times. A special request was made to analyze samples at 17 wells for Aroclor-1262, Aroclor-1268, isodrin, and kepone. One mercury sample was lost by the analytical laboratory. Arsenic levels exceeded the primary drinking water standard in downgradient wells 807 and 809; iron levels exceeded the secondary drinking water standard in downgradient wells 806, 807, 809, 810, 812, 813, 815, 816, 820, 823, 828, 829, 830, and 946 and in upgradient well

819; manganese levels exceeded the secondary drinking standard in downgradient wells 806, 807, 809, 820, 810, 823, 824, 827, 829, 830, and 946 and in upgradient well 819; and chromium exceeded state water quality standards at well 812.

Specific conductance, pH, and temperature were within normal ranges for groundwater in this area. Fluoride content in wells 811 and 808 exceeded the state of Tennessee limit of 1.4–2.4 mg/L but not the EPA primary drinking water standard of 4.0 mg/L. Low levels of radionuclides detected in several wells included tritium, total radioactive strontium, ^{234}U, and gross alpha and beta activity. Total radioactive strontium exceeded the drinking water standard in wells 806, 812, 829, 830, and 946. Of these, only wells 806, 812, and 830 exceeded the value currently accepted to represent 4 mrem/year (41 pCi/L). Well 812, a shallow well in which the water table is only a few feet below ground surface, contained as much as 8100 pCi/L total radioactive strontium and 220 pCi/L ^{234}U. Efforts to evaluate the origin and extent of radioactive contamination in this well and the low levels of radioactivity in several other wells in WAG 1 are continuing. Additional data will be required to verify these results.

WAG 5 results

Perimeter wells at WAG 5 were sampled once during 1990 between July 31 and August 16. A summary of the analytical results by well type, upgradient and downgradient, is presented in Table 4.14 in Vol 2. The two upgradient wells appear to be generally unaffected by contamination. Tritium was detected in both wells at 49 pCi/L (i.e., 0.06% of the DCG).

Most WAG 5 wells contained ^{3}H; concentrations were the highest along the south and west perimeters with values ranging from 73,000 pCi/L (4% DCG) to 23,000,000 pCi/L (1150% DCG). Based on the first set of sample data, no association appears evident between ^{3}H concentration and depth.

Total radioactive strontium is the major beta emitter other than ^{3}H found in WAG 5 groundwater; it was detected only in shallow wells. Six values exceeded the primary drinking water standard of 8.0 pCi/L for ^{90}Sr. They ranged from 540 pCi/L (20 Bq/L) to 8.1 pCi/L (0.30 Bq/L). None of total strontium values exceeded the DCG of 1000 pCi/L.

Gross beta values exceeding the primary drinking water standard are 620 pCi/L (23 Bq/L) at well 975, 210 pCi/L (7.8 Bq/L) at well 973, 97 pCi/L (3.6 Bq/L) at well 969, and 68 pCi/L (2.5 Bq/L) at well 971. In most cases the source of the gross beta appears to be the radioactive strontium. Gross alpha values exceeding the primary drinking water standard are 29 pCi/L (1.1 Bq/L) at well 982 and 18 pCi/L (0.67 Bq/L) at well 973. The radionuclide contribution to the gross alpha signature is yet to be determined.

In summary, the primary radionuclides found in WAG 5 groundwater are ^{3}H and radioactive strontium; ^{3}H appears to be prevalent in most wells but is highest along the south and west perimeters. Radioactive strontium is found in the shallower wells on the south perimeter.

WAG 6 results

The perimeter wells at SWSA 6 were sampled twice during 1990, once during May and June, and once during October and November. A summary of the analytical results is presented in Table 4.15 in Vol. 2. Results obtained during the 1990 sampling periods were comparable to those obtained during 1988–1989 detection monitoring. The observed differences involved, in nearly every case, general water quality parameters, pH, conductivity, and temperature. In most of these cases the differences were slight.

With the exception of well 824, only pH and ^{3}H exceeded regulatory reference values. In the case of pH, wells either quite alkaline or acidic are characteristic of background water at those depths. Tritium reference values were exceeded in samples from downgradient wells on the northeast corner of SWSA 6.

At well 842 both carbon tetrachloride (73 μg/L and 33 μg/L) and trichloroethene (320 μg/L and 310 μg/L) were observed at values in excess of regulatory reference values.

Several analytes that are commonly acknowledged to be laboratory contaminants were detected below their quantitation limits. They are acetone, methylene chloride, and toluene.

During the second 1990 sampling period, 1,1-dichloroethene was detected at below quantitation level. Carbon disulfide was quantified at 110 μg/L in the autumn sample from well 860. It was also present in the trip blank at 9.0 µg/L during this sampling period. Although the well 860 value is high enough to give confidence that it is real and not an artifact of laboratory procedures, this was the first and only occurrence of its apparent presence at this well since the initiation of sampling. The location of the well is such that contamination would not be expected. Further, the presence of carbon disulfide in the absence of any of the other more likely contaminants for SWSA 6 wastes is highly unlikely. Thus, this value is considered spurious. Two other values obtained at two other wells during the autumn sampling period are near the detection limit and are considered questionable.

In summary, groundwater quality at the perimeter of SWSA 6 has not materially changed since detection monitoring began in June 1988. Results from four additional wells located outside the east boundary of SWSA 6 indicate that volatile organic contamination associated with wells 841 and 842 is a localized phenomenon. Wells 841, 842, 843, and 847, where observed values exceeded the regulatory reference value for ^{3}H, will be sampled quarterly in 1991.

WAG 7 results

Perimeter wells at WAG 7 were sampled once during 1990, between June 7 and June 25. A summary of the analytical results by well type, upgradient and downgradient, is presented in Table 4.16 in Vol 2. The two upgradient wells appear to be generally unaffected by contamination. However, ^{137}Cs was detected in one well, and total radioactive strontium was detected in the other well.

Fluoride at well 1075 (6.5 mg/L), nitrate at wells 1079 (1,900 mg/L) and 1078 (38 mg/L), and Ni at wells 1079 (0.36 mg/L) and 1085 (0.24 mg/L) exceed primary drinking water standards. The sample from well 1078 contained concentrations of ^{99}Tc and ^{60}Co exceeding 4% of their respective DCGs; this is equivalent to 4 mrem/year drinking water standard. A gross alpha value of 300 pCi/L (11 Bq/L) from well 1079 exceeded the primary drinking water standard. The radionuclide contribution to this value is yet to be determined.

Four gross beta concentrations exceeded the primary drinking water standard. In all cases these values corresponded to the results for ^{99}Tc and ^{60}Co.

Concentrations of ^{3}H were quite high at the west (next to SWSA 6) and south (along WAG 2) perimeter wells. Five values exceeded 4% of the DCG. Except for well 1079 on the west side of WAG 7 next to SWSA 6, high concentrations of ^{3}H were found in shallower wells.

In summary, the primary radionuclides found in WAG 7 groundwater are ^{3}H, ^{99}Tc, and ^{60}Co; ^{3}H appears to be prevalent in most wells but is highest along the west perimeter next to SWSA 6. Some fluoride, nickel, and nitrate values exceeded the primary drinking water standards.

4.3.2.4 Future ORNL groundwater quality monitoring activities

The Groundwater Quality Assessment Plan for SWSA 6 will continue to be implemented in 1991. Wells 840–844, 847, and 1242–1245 will be sampled quarterly to further understand the extent of contamination at SWSA 6. The remaining wells at SWSA 6 will be sampled semiannually during 1991.

WAG 1, WAG 5, and WAG 7 will be sampled semiannually during 1991.

The planned sequence for sampling and analysis of groundwater from the remaining seven WAGs is based on the nature and inventory of contaminants at the WAG; near-term release potential; position relative to other potential, hydrologically upgradient sources; regulatory considerations; and costs and funding availability. The sequence as presently projected is WAGs 4, 2, 17, 8, 3, 9, and 11; these wells will be sampled semiannually during 1991.

4.3.3 K-25 Site

4.3.3.1 Background

Thirteen hydrogeologically defined WAGs, encompassing from one to more than ten individual waste units, have been defined at the K-25 Site. All 191 existing groundwater monitoring wells are located within these 13 WAGs. A fourteenth WAG was designated to encompass the surface investigations at the K-1070-C/D burial ground unit, although groundwater contamination from this site will be addressed under WAGs 1 and 2. Table 4.10 lists the 13 WAGs at the K-25 Site and the number of sites within each WAG. Figure 4.7 shows the locations of each of the WAGs.

The general approach to groundwater investigations in each of the WAGs is described in Sect. 3 of the *K-25 Site GWPP Management Plan*. The preliminary assessment/site evaluation (PA/SE) phase of the investigation includes installation of wells immediately surrounding each unit in a WAG suspected of being a source of groundwater contamination, a year of baseline monitoring in each of those wells, and evaluation and interpretation of the data produced. Plans for subsequent remedial investigations, if necessary, will be determined on the basis of the results of the PA/SE. The schedules for these investigations have been defined in the Oak Ridge Reservation Federal Facilities Agreement.

Samples from many wells throughout the plant area indicated high concentrations of iron and manganese in the groundwater. In general, these constituents are not considered in assessing contamination of the area because they occur naturally in high concentrations in the underlying geologic formations.

A summary of the 1990 groundwater monitoring data for the K-25 site is presented in Table 4.17 of Vol. 2. These data tables include the parameters for which concentrations above detection limits were detected. The reference values used in the table refer to the most recent MCLs and primary and secondary drinking water standards.

4.3.3.2 WAG 1 RCRA units

K-1407-B Pond

The K-1407-B Pond is an RCRA interim status unit currently in detection monitoring. This surface impoundment was used for settling the metal hydroxide precipitates generated during the neutralization and precipitation of metal-laden solutions treated in the K-1407-A neutralization pit. Potential contaminants are heavy metals. The unit was removed from service during 1988 and is undergoing RCRA closure. A postclosure permit application has been submitted to TDC.

Data that had indicated an increase of conductivity and total organic halogens (TOX) were analyzed in the report, *K-1407-B and K-1407-C Surface Impoundment False Positive Groundwater Assessment*. The report was approved by the TDC on March 10, 1989, and describes laboratory analyses from samples collected between November 1987 to December 1988. According to its recommendations, the monitoring program for both the B and C Ponds was modified to remove the possibility for future false-positive readings.

The groundwater quality monitoring wells at the B-Pond were sampled twice in 1990. In March and September, statistically significant concentrations of manganese were noted. However, the manganese concentrations are considered to be a reflection of the natural groundwater quality. Wells UNW-3 and UNW-4 exhibited statistically significant concentrations of cadmium for the September sampling event. In accordance with the modified detection program, these wells were resampled in January 1991. The second set of samples from these wells indicated that the high cadmium concentrations noted earlier were probably the result of sampling or laboratory error.

The upgradient well for the B-Pond, UNW-1, has shown significant increases in specific conductance. There has been a trend of increasing specific conductance at this well since 1987 and it has been hypothesized to be indicative of approaching contaminants from an upgradient source.

K-1407-C Pond

The K-1407-C Pond is a RCRA interim status unit currently in detection monitoring. This surface impoundment was used primarily for storing potassium hydroxide scrubber sludge, although sludges from B-Pond also were placed here prior to 1973. Potential contaminants are heavy metals. The C-Pond is undergoing RCRA closure. The monitoring program for this unit also was changed to a modified detection program. This monitoring program for the C-Pond was approved on July 11, 1988.

Sampling for this site took place in March and September, as it was for the B-Pond. The results of statistical analysis selected parameters at the K-1407-C Pond indicated significant concentrations of manganese at wells UNW-7, UNW-9, and UNW-10 for the March sampling event and at UNW-9 for September. Statistically significant results were also obtained for pH in well UNW-8 for the March sampling event. The well was resampled

Table 4.10. Summary of K-25 Site Waste Area Groupings (WAGs)

WAG	Description	Waste Management Sites	Number of wells
1	K-1700 Area	K-1407-A K-1407-B K-1407-C K-1070-B K-1401 K-1413 K-1420 K-1070-C,D K-1503	53
2	K-1004 Area	K-1070-C,D K-1414 K-1004-J K-1004-Drain K-1004-L K-1004-N K-1007	44
3	K-1099 Area	K-1099	1
4	K-1064 Area	K-1064-G	12
5	K-1410 Area	K-1410	2
6	K-1232 Area	K-1232	6
7	K-27/29 Area	K-27/29 K-832-H K-1203	12
8	K-1070-F	K-1070-F	5
9	K-31/33	K-31 K-33 K-862-E K-892-G,H K-892-J	22
10	K-901-A Area	K-901-A K-1070-A	18
11	K-770 Area	K-770	7
12	K-720 Area	K-720	4
13	K-1085 Area	K-1085	5

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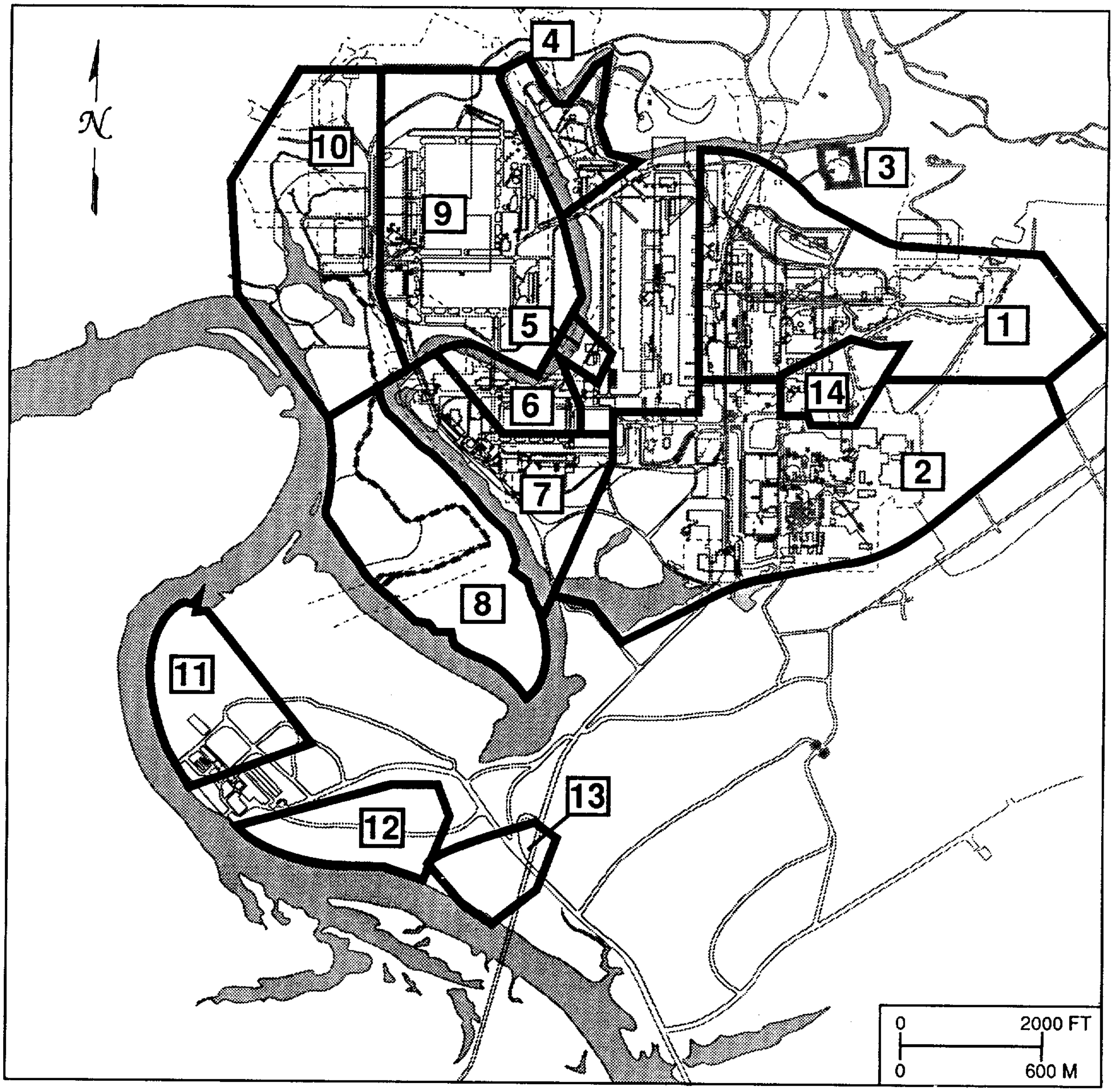

Fig. 4.7. Locations of Waste Area Groupings (WAGs) in the K-25 Site area.

and the pH results were no longer statistically significant, suggesting that the March result may have been a sampling error, analytical error, or natural fluctuation of the groundwater quality.

4.3.3.3 WAG 1

K-1413 process lines and sumps

The K-1413 Area includes four components: the K-1413-C Neutralization Pit, two smaller pits (sumps) located to the north and east of the K-1413 building, the lines from the pits to the K-1401 Acid Line, and the storm drains in the vicinity of the K-1413 building. The capacity of the sumps is about 500 to 1000 gal (1893 to 3785 L) each. Corrosive wastewater and metal hydroxides drain from the two sumps to K-1407-A for neutralization. Potential contaminants at the site include organic solvents and uranium from early uranium fluorination activities at the site.

K-1401 acid line and degreaser tanks

The K-1401 acid line is an underground vitreous clay pipeline used to transport corrosive fluids from the K-1491 degreaser tanks to the K-1407-A Neutralization Pit for neutralization. The K-1401 degreaser tanks are stainless steel tanks in brick-lined pits within a large concrete structure in the K-1401 building. Equipment is lowered into the tanks for degreasing, and trichloroethane is used as the solvent. Both of these facilities are still in use.

K-1420 oil storage area and process lines

The K-1420 oil storage area consists of a paved area 50 (15.2 m) by 275 ft (84 m), located 75 ft (23 m) north of the K-1420 building. Uranium-contaminated oil is stored at the facility in 19-L (5-gal) buckets for transfer to 209-L (55-gal) drums and is then transported to the waste-oil decontamination facility inside K-1420. The K-1420 process lines are underground pipelines that connected K-1420 to the K-1407-B Pond for transport of radioactive liquid. One of the abandoned pipelines was found to contain PCBs, mercury, and uranium.

K-1503 Neutralization Pit

The K-1503 Neutralization Pit was used for neutralization of corrosive liquids generated in water-softening operations in the past. Currently, it is used only as a sump for temporarily holding of corrosive liquids. It is approximately 10 ft^2 (3.1 m^2) by 12 ft (3.7 m) deep.

Results of analyses from groundwater quality wells in WAG 1 (excluding K-1407-B and K-1407-C Ponds) indicate the presence of radionuclides including strontium, ^{99}Tc, and ^{234}Th. Gross alpha and gross beta values exceeded primary drinking water standard values. The maximum gross alpha value is 45 pCi/L; the gross beta value, 116 pCi/L. A summary of the analytical results by WAG is presented in Table 4.17 in Vol. 2.

Chromium, mercury, and trichloroethene exceeded primary drinking water standards. Chloride, iron, and manganese exceeded secondary drinking water standards. Values for pH ranged from a minimum of 4.7 to a maximum of 7.5.

4.3.3.4 WAG 2

K-1414 Fuel Storage Center

The K-1414 Fuel Storage Center has had three steel USTs containing automotive fuel. One 5500-gal (20,818-L) tank contains unleaded gasoline, a second 12,000-gal (45,420-L) UST contains methanol, and the third UST was removed after it was found to be leaking diesel fuel in February 1987. An Environmental Assessment and a Remedial Action Program (RAP) were completed in 1989. The RAP was submitted to TDC and was conditionally approved. A bioremediation system for this site has been designed. Remedial activities are scheduled to begin in 1991.

K-1004 Area laboratory drain, K-1004-L vaults, and K-1004-N cooling tower basin lines and RCW lines

The K-1004 Area Laboratory Drain carries wastes from several laboratories to the K-1007-B holding pond. The drain was used for disposal of laboratory wastes prior to receipt of an NPDES permit in 1984. The drain is now used for disposal of rinse water only.

The K-1004-L vaults contain concrete casks that were used in the 1950s and 1960s for storage of reactor return samples. The K-1004-N cooling tower basin is a 30- to 40-year-old above-ground tank that is 21 ft (6.4 m) long by 21 ft (6.4 m) wide by 3 ft (0.9 m) deep. The K-1004-L RCW lines circulated cooling water between the K-1004-L building and the K-1004-N cooling tower. Potential contaminants are chromium zinc, phosphate, other heavy metals, and radioactivity.

K-1007 underground gasoline storage tank

The K-1007 gasoline storage tank was a 250-gal (946-L) tank located north of the K-1007 building. The top of the tank was 6 to 8 ft (1.8 to 2.4 m) below ground. Gasoline was observed in the soil surrounding the tank when it was excavated and removed in 1986. Contaminants expected from this source are volatile organic aromatics (VOAs), petroleum hydrocarbons, and lead.

Total coliform and trichloroethene analyses in WAG 2 exceeded the primary drinking water standards. Trichloroethene was detected in 10 of the 23 samples analyzed. Iron and manganese exceeded secondary drinking water standards.

4.3.3.5 WAG 4

K-1064-G Burn Area/Peninsula Storage

The K-1064-G Burn Area/Peninsula Storage Area was used in the 1950s and 1960s for burning solvents in an open metal container and in the 1960s and 1970s for drum storage of potential contaminants such as organic solvents, PCBs, and radioactively contaminated waste oils. The drums were removed, and the unit closed in 1979.

From all samples analyzed, only iron and manganese were detected above drinking water standards in WAG 4.

4.3.3.6 WAG 5

K-1410 Neutralization Pit

The K-1410 Neutralization Pit is a 15,800-gal (59,803-L) concrete tank used from 1975 to 1979 for the neutralization of nickel-plating solutions prior to discharge to Poplar Creek. Some of the other chemicals known to be included are nickel sulfate, degreaser bath, acid, and corrosive solutions.

Concentrations of trichloroethene in WAG 5 were detected above primary drinking water standards. The only metals to be detected above drinking water standards were iron and manganese.

4.3.3.7 WAG 7

K-27/29 RCW lines

Two RCW lines, located in the WAG 7 area, are being investigated for possible groundwater contamination caused by leakage. RCW lines are underground steel pipes that circulated treated cooling water between the cooling tower basins and the process buildings. They are buried from 3 to 10 ft (9 to 3 m) below grade and range from 16 to 64 in. (41 to 163 cm) diam. Most were in use from the 1950s to 1985. Potential contaminants include chromium, zinc, phosphate, other heavy metals, and radioactivity.

K-832-H Cooling Tower Basin

K-832-H is one of the cooling tower basins being evaluated for possible groundwater contamination. The basins are large, rectangular, concrete basins that are 300 to 400 ft (91.4 to 121.9 m) long, 50 to 65 ft (15 to 20 m) wide, and 13 to 16 ft (4 to 5 m) deep (mostly below grade). Capacities range from 2.4 to 5.8 million gal (9.1 to 22 million L). The basins underlie cooling towers and were used for recirculating chromate, zinc, and phosphate-treated cooling water.

The maximum trichloroethene value (0.17 mg/L) was detected in UNW-38, which is located near K-27. Chromium, detected in 24 of the 42 samples, was the only metal to exceed primary drinking water standards. Iron and manganese exceeded secondary drinking water standards. Analyses for coliform bacteria and field pH measurements also exceeded drinking water standards.

4.3.3.8 WAG 9

K-31, K-33 RCW lines

Two additional RCW lines are being investigated for possible groundwater contamination by leakage.

K-862-E, K-892-G,H, K-892-J cooling tower basins

These sites are cooling tower basins that are also being evaluated for possible groundwater contamination.

Heavy metals that exceeded drinking water standards are cadmium, chromium, and sulfate. Iron and manganese values exceeded secondary drinking water standards. The maximum value of trichloroethene was detected at BRW-67, located near K-33. Values for pH were recorded as low as 5.6, less than the minimum drinking water standard value. Analyses from this WAG also indicated the presence of coliform bacteria.

4.3.3.9 WAG 10

K-901-A Holding Pond

The K-901-A Holding Pond is a surface impoundment of approximately 5 acres located adjacent to the Clinch River. The pond was built in the early 1970s and was in use until 1985 for settling chromium-hydroxide (trivalent chromium) precipitates generated by electrochemical treatment of chromated RCW blowdown. The pond contains sludge composed of these chromium-hydroxide precipitates along with lead, nickel, copper, and uranium.

Chromium was detected in 3 of 24 samples and exceeded drinking water standards. The solvents detected above drinking water standards in groundwater samples are 1,1-dichloroethene and trichloroethene. Bacterial coliform, iron, and manganese were also detected. Readings for pH were recorded below secondary drinking water standards.

4.3.3.10 WAG 12

K-720 Fly Ash Pile

The K-720 Fly Ash Pile is located southwest of the K-25 Site near the east bank of the Clinch River. Fly ash was generated during the 1940s and 1950s by the nearby coal-powered steam plant. The pile covers an area of 10 to 15 acres (4 to 6 ha). Potential contaminants include heavy metals, sulfates, and radioactivity.

Of the samples collected from WAG 12 in 1990, the maximum values of cadmium (0.018 mg/L), sulfate (17,600 mg/L), and iron (82 mg/L) were detected above drinking water standards in well UNW-74. Manganese and pH also exceeded drinking water standards.

Future K-25 Site Groundwater Protection Program activities

Four environmental surveillance wells and 19 ER and background wells are planned for installation at the K-25 Site during FY 1991.

4.4 PLUGGING AND ABANDONMENT

An open borehole or well may provide a potential route for surface contamination to enter previously uncontaminated groundwater. Transfer or spread of contamination from one zone to another occurs when an open borehole provides a pathway for contaminated water in an aquifer to enter or mix with that in an uncontaminated aquifer. Mixing in the subsurface can confuse monitoring results and spread contamination. To minimize the potential for groundwater cross-contamination, a program was initiated to identify, plug, and abandon unused, unnecessary, or damaged boreholes.

4.4.1 Y-12 Plant

On April 18, 1988, DOE received conditional approval from the TDC of a plugging and abandonment procedure for selected groundwater wells at the Y-12 Plant.

No wells were plugged in 1990, although 90 to 100 candidates have been identified for future action. A contract was put in place for development of a plugging and abandonment plan.

4.4.2 Oak Ridge National Laboratory

Nine groundwater monitoring wells were plugged in 1990 in SWSA 6 at the Interim Waste Management Facility (IWMF). They were installed as part of the initial site characterization activities to assess the subsurface geology and shallow groundwater characteristics. These wells were removed because they are no longer needed for site characterization or groundwater monitoring activities. The well designations were NAT-64, T-5, T-10, T-17, T-18, T-20, T-22, T-27, and T-36.

Currently, activity is devoted to the development of a well plugging and abandonment plan for

Table 4.11. Constituents in off-site groundwater during 1990

Analyte	Number detected	Number of samples	Values above detection limit			Reference value[c]	Number of values exceeding reference [ref][d]
			Max[a]	Min[a]	Av[b]		
Anions (mg/L)							
Chloride	21	21	62	1.0	6.1*	250	0[3]
Fluoride	13	21	6.0	0.10	0.68	4.0	1[2]
Nitrate	11	21	17	2.0	4.3*	10	1[2]
Sulfate as SO_4	21	21	51	2.0	13*	200	0[3]
Field measurements							
Conductivity (mS/cm)	21	21	1.2	0.11	0.29*	*e*	[*e*]
pH (standard units)	21	21	9.2	6.9	7.5*	(6.5, 8.5)	2[3]
Temperature (°C)	21	21	24	14	19*	31	0[1]
Metals							
Arsenic, total (mg/L)	1	21	0.0050	0.0050	0.0050	0.050	0[2]
Barium, total (mg/L)	16	21	0.32	0.0097	0.093*	1.0	0[2]
Calcium, total (mg/L)	21	21	93	1.8	43*	*e*	[*e*]
Cadmium, total (mg/L)	7	21	0.022	0.0033	0.0096*	0.010	2[1]
Cobalt, total (mg/L)	1	21	0.0081	0.0081	0.0081	*e*	[*e*]
Copper, total (mg/L)	20	21	0.21	0.0042	0.029*	1.0	0[1]
Iron, total (mg/L)	13	21	10	0.0047	1.7	0.30	5[3]
Magnesium, total (mg/L)	21	21	29	0.69	14*	*e*	[*e*]
Manganese, total (mg/L)	6	21	0.73	0.0090	0.19	0.050	5[3]
Sodium, total (mg/L)	21	21	340	0.49	31*	*e*	[*e*]
Nickel, total (mg/L)	1	21	0.010	0.010	0.010	0.10	0[1]
Lead, total (mg/L)	9	21	0.027	0.0041	0.011*	0.050	0[1]
Uranium, total (mg/L)	4	21	0.0010	0.0010	0.0010	*e*	[*e*]
Uranium, total[f] (pCi/L)	4	21	0.66	0.66	0.66	*e*	[*e*]
Zinc, total (mg/L)	20	21	1.1	0.0034	0.15*	5.0	0[1]
Radionuclides (pCi/L)							
^{60}Co	1	21	7.0	7.0	7.0	200	0[4]
Gross alpha	20	21	4.6	1.1	3.1*	15	0[2]
Gross beta	19	21	51	4.9	10*	50	1[2]
^{99}Tc	5	21	2.3	0.95	1.6*	4,000	0[4]
$^{89}Sr + {}^{90}Sr$	11	21	3.5	0.73	1.5*	40	0[4]
Tentatively identified compounds (μg/L)							
Cyclohexane	8	8	6.0	JB 5.0	5.6*	*e*	[*e*]

[a]Prefixs J and B mean that the value was estimated or found in the laboratory blank, respectively.
[b]An asterisk (*) follows a mean that is significantly greater than zero.
[c]If a reference limit exists, the source is coded as:

1. Rules of Tennessee Department of Health and Environment, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, February 1987.
2. 40 CFR (7-1-1989 Edition) Part 141—National Primary Drinking Water Regulations, Subpart B-Maximum Contaminant Levels.
3. 40 CFR (7-1-1989 Edition) Part 143—National Secondary Drinking Water Regulations.
4. DOE Order 5400.5, February 8, 1990. Chapter III, Derived Concentration Guides for Air and Water.

[d]The source of the reference limit is enclosed within brackets.
[e]Not applicable.
[f]Activity is calculated from mass assuming natural abundance.

SWSA 6. Field verification (location and well construction) of wells is ongoing. When the site is permanently closed, all wells will be plugged except those peripheral monitoring wells necessary for closure.

4.4.3 K-25 Site

No wells were plugged and abandoned at the K-25 Site during 1990.

4.5 OFF-SITE MONITORING

Under the direction of the Energy Systems Environmental and Safety Activities (E&SA) Organization, ORNL implemented a long-term, off-site, residential drinking water quality monitoring program in 1989. The objective of the program is to document water quality from groundwater sources in areas adjacent to the ORR and to evaluate the impact of DOE-ORO plant operations on the quality of these groundwater sources.

Twenty-one wells were selected on the basis of their proximity to the ORR and a representative distribution of sources from the different geologic formations of the area. The wells were sampled once during 1990. Analytical parameters used for monitoring include volatile organics; selected atomic absorption metals (As, Hg, Pb, and Se); inductively coupled argon plasma metals; anions (fluoride, chloride, sulfate, nitrate, and nitrite); total fluorometric uranium; and the radioactivity parameters gross alpha, gross beta, total radioactive strontium, ^{99}Tc, ^{3}H, and radionuclides observed in a gamma scan. These data are presented in Table 4.11.

Six of the wells had parameter concentrations exceeding primary drinking water standards. Those parameters were cadmium in one well, fluoride in one well, nitrate and cadmium in one well, and gross beta in one well. The gross beta value was obtained from a well located at the perimeter of the ORR.

BIOLOGICAL SAMPLING

5. BIOLOGICAL SAMPLING

Air and water are the principal dispersal media for the Oak Ridge DOE facility releases. However, the environmental surveillance programs also include biotic and other abiotic media that may be affected by these releases or may provide pathways of exposure to people. This section gives a summary of the media sampled, the types of analyses performed, and the sampling and analysis frequencies for the biological samples.

One of the problems encountered when analyzing samples for uranium isotopes is the high bias associated with the ^{235}U activity. When a stainless steel disk containing a mixture of ^{234}U, ^{235}U, and ^{238}U is counted with a silicon surface barrier detector, the ^{235}U activity is often biased because of interference from the ^{234}U and ^{238}U. The ^{235}U alpha energy lies between the other two isotopes, and the detectors do not have sufficient resolution to separate all three peaks effectively. Therefore, depending on the amount of ^{234}U and ^{238}U present in the sample, the ^{235}U result will appear to be higher than it actually is.

5.1 MILK

One of the pathways of radioactivity to man is ingestion. Radionuclides can be transferred from the environment to humans via food chains such as the grass-cow-milk pathway. Milk is a potentially significant source to humans of some radionuclides deposited from airborne emissions because of the relatively large surface area that can be grazed daily by the cow, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet.

5.1.1 Sample collection and analytical procedures

The 1990 milk sampling program consisted of monthly grab samples collected from five locations in the vicinity of the Oak Ridge Reservation. Figure 5.1 shows the locations of the stations.

Milk samples are analyzed at ORNL for ^{131}I by gamma spectrometry and for total radioactive strontium (^{89}Sr and ^{90}Sr) by chemical separation and low background beta counting.

5.1.2 Results

Concentrations of ^{131}I and total radioactive strontium in milk are summarized for the 1990 data in Table 5.1. The average values were converted to effective dose equivalents and are presented in Sect. 7, Potential Radiation and Chemical Dose to the Public. These results are consistent with data from previous years. The location-specific data are included in Vol. 2, Tables 5.1 and 5.2.

5.2 FISH

Ingestion of fish is a pathway for contaminant uptake in man. Prior to 1985, five species of fish were measured for PCBs, mercury, and radionuclide concentrations: bluegill, catfish, bass, carp, and crappie. The highest mercury and PCB concentrations were found in carp, and the next highest were in bluegill. For several of the radionuclides, concentrations were highest in bluegill. Because of this and because of the large number of available fish, bluegill (*Lepomis macrochirus*) were collected during 1990 for tissue analysis to estimate concentrations for dose assessment models. In addition, bluegill are favored by sport fishermen in Tennessee and can be obtained in the large numbers required for tissue analysis. Additional information on bioaccumulation of contaminants by fish is provided in Special Studies, Sect. 9.4, Biological Monitoring and Abatement Program.

5.2.1 Sample collection and analytical procedures

Bluegill from three Clinch River locations were collected twice during the year for muscle analyses of

Table 5.1. 1990 radionuclide concentrations in raw milk[a]

Analysis	Number of samples	Concentration (pCi/L)			
		Max	Min	Av[b]	Standard error[c]
^{131}I	56	2.7	–2.4	–0.13	0.15
Total Sr[d]	56	17	–0.19	2.7*	0.35

[a]See Fig. 5.1.
[b]An asterisk (*) indicates that the average is significantly greater than zero at 95% confidence level.
[c]Standard error of the mean.
[d]Total radioactive strontium (^{89}Sr + ^{90}Sr).

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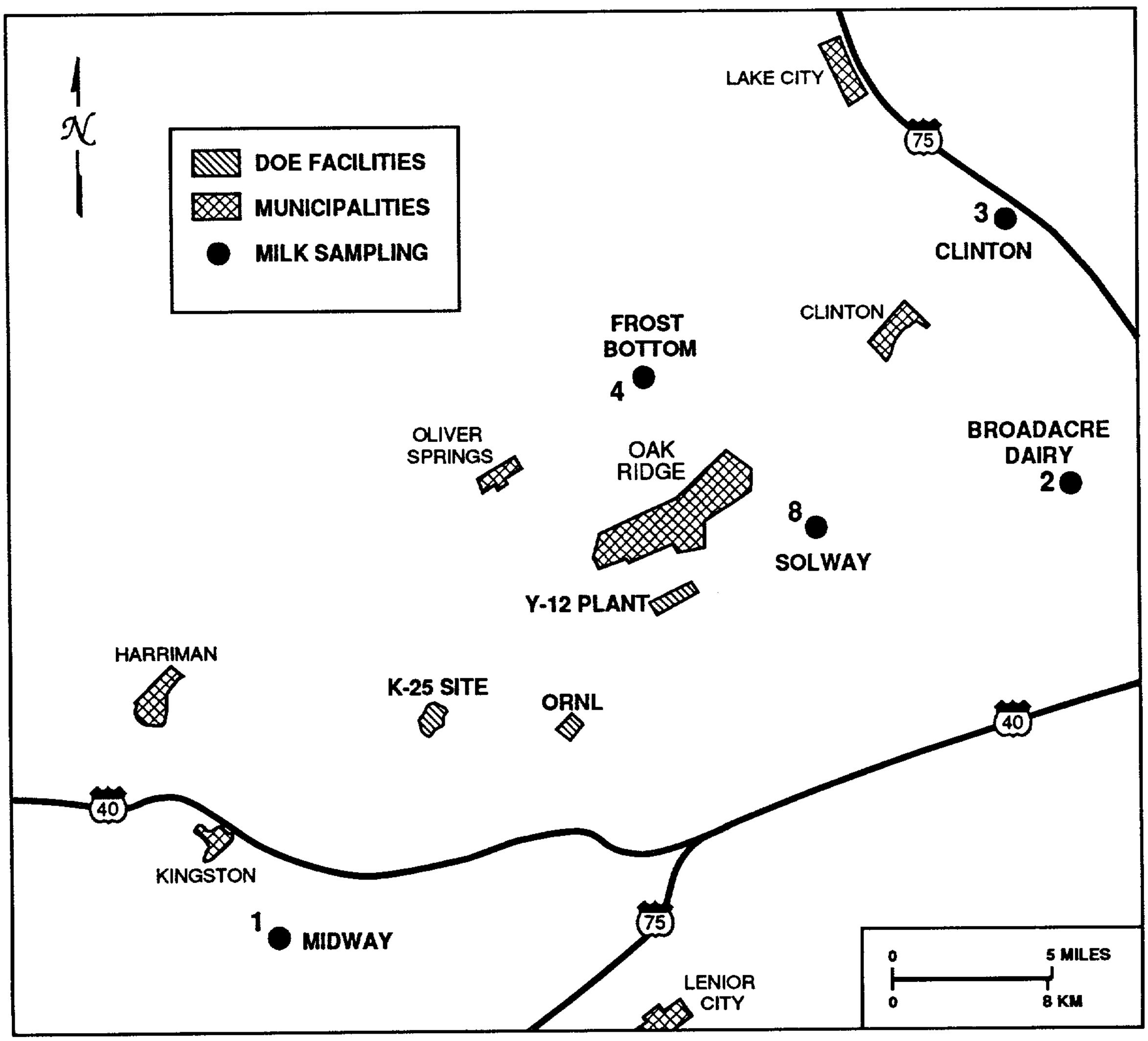

Fig. 5.1. Map showing milk sampling stations.

Table 5.2. 1990 tissue concentrations of Clinch River bluegill[a]

Analysis	Number of samples	Concentration[b]			
		Max	Min	Av[c]	Standard error[d]
^{60}Co	18	0.54	–0.11	0.13*	0.038
^{137}Cs	18	26	0.41	6.4*	1.8
Total Sr[e]	18	5.4	–0.027	0.97*	0.31
Hg	36	0.46	<0.025	<0.13	0.014
PCB Aroclor 1254	36	<0.54	<0.010	<0.15	0.027
PCB Aroclor 1260	36	<0.54	0.010	<0.16	0.026

[a]See Fig. 5.2.

[b]Radionuclides are in pCi/g ash weight. Mercury and PCB units are μg/g wet weight.

[c]* For radionuclides, an asterisk (*) indicates that the average is significantly greater than zero at the 95% confidence limit.

[d]Standard error about average.

[e]Total radioactive strontium (^{89}Sr and ^{90}Sr).

radionuclides, mercury, and PCBs (Fig. 5.2; Table 5.2) by ORNL. Sampling locations include three Clinch River kilometer locations (CRKs). The first location is CRK 40.0 (river mile 24.8), which is above Melton Hill Dam and serves as a background location for the DOE facilities. It is above all the Oak Ridge DOE facilities' outfalls with the exception of those from the ORNL 7600 area, the radioactive effluents from which are negligible. The second sampling location is CRK 33.3 (river mile 20.6), which is ORNL's discharge point from White Oak Creek to the Clinch River. The third location is CRK 8.0 (river mile 5), which is downstream from both ORNL and the K-25 Site.

The primary radionuclides of concern at ORNL regarding fish consumption are total radioactive strontium and ^{137}Cs. These two result in the highest dose to man from ingestion of fish. Radionuclide concentrations were determined on at least three composites of six to ten fish per sampling period. Mercury and PCB concentrations were measured in six individual fish from each sampling location during each period. Each fish was filleted, and only the muscle tissue was used for analysis. Composite samples were ashed and analyzed by gamma spectrometry and radiochemical techniques for the radionuclides that contribute the majority of the potential radionuclide dose to humans.

The ash typically constitutes 1% of the original sample. DOE Order 5400.1 requires that concentrations be reported in pCi/g ash weight. The 1990 concentration data has also been converted to a wet weight basis and presented in Vol. 2, Table 5.5.

5.2.2 Results

Concentrations of mercury, PCBs, ^{60}Co, ^{137}Cs, and total radioactive strontium in bluegill collected in the Clinch River are given in Table 5.2, which provides a summary of the highest, lowest, and average concentrations of these parameters observed in bluegill from any of the three Clinch River locations. Information regarding potential health impacts associated with these data is provided in Sect. 7, Potential Radiation and Chemical Dose to the Public.

Annual mercury concentrations in bluegill from the three Clinch River sampling locations are given in Table 5.3 of Vol. 2. An analysis of variance test was used to compare concentrations of parameters in fish from the different locations. Mercury concentrations were significantly higher in fish from CRK 8.0 (river mile 5) than CRK 33.3 (river mile 20.7) and CRK 40.0 (river mile 25). The highest concentration of mercury was measured at CRK 8.0 (0.46 μg/g wet weight). This relationship among the locations is consistent with data from 1988 and 1989.

PCB concentration summaries for bluegill for 1990 are given in Table 5.4 of Vol. 2. Of the 72 individual fish samples that were analyzed for PCB

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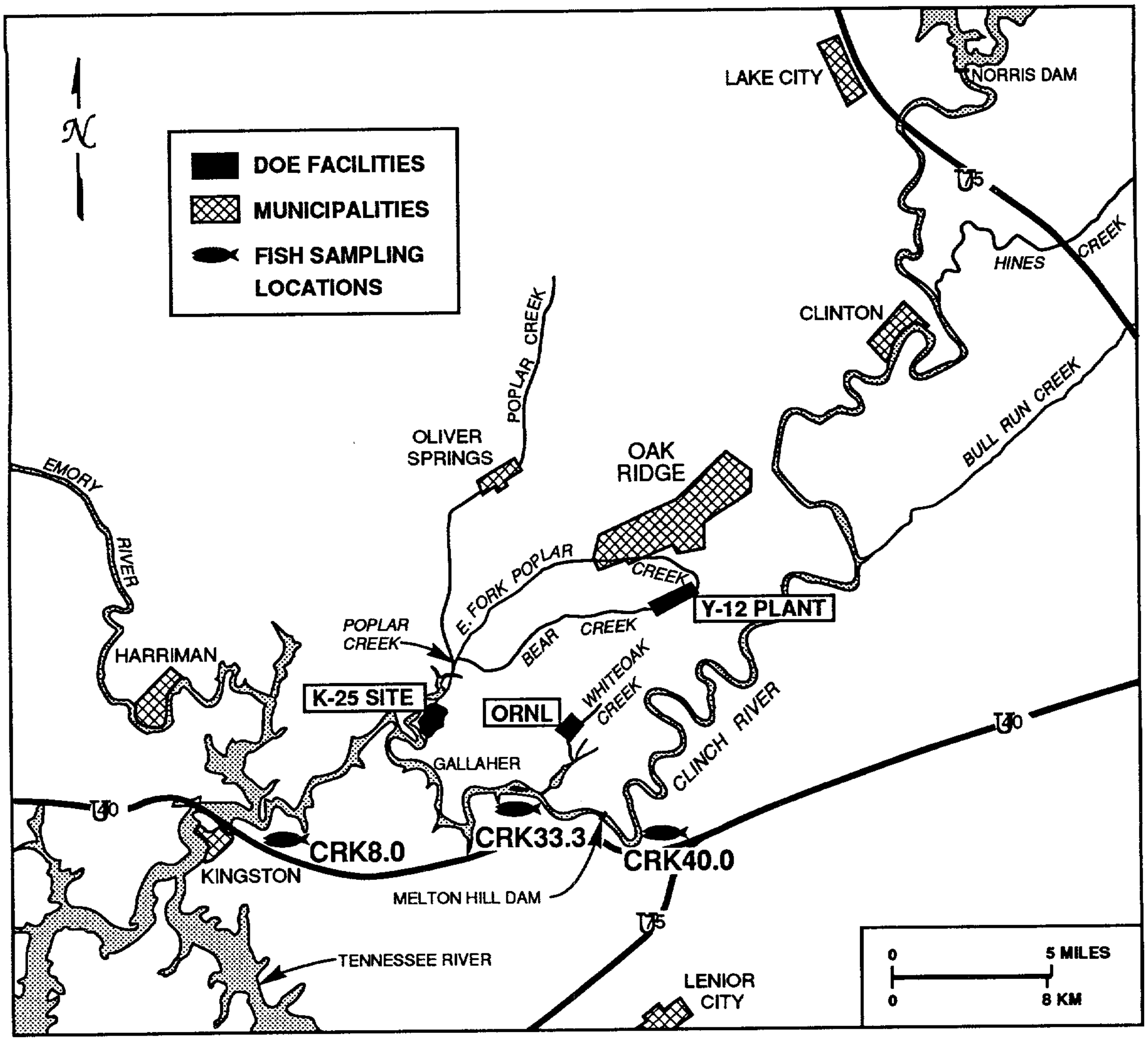

Fig. 5.2. Fish sampling locations along Clinch River.

Aroclors, 16 results were above the analytical detection limit. Two of the values were for Aroclor 1254. Both of these results were from CRK 8.0 (river mile 5). The other 14 results were for Aroclor 1260. These data were distributed among the three sampling sites and were not statistically different at a confidence level of 95%.

Annual summaries of radionuclide concentrations in Clinch River fish are given in Table 5.5, Vol. 2. No statistically significant differences in ^{60}Co were detected in fish collected at the three locations. Total radioactive strontium values for fish from CRK 33.3 were higher than the other two stations, but the difference was not statistically significant at the 95% confidence limit. Concentrations of ^{137}Cs in fish were significantly higher in fish collected at CRK 33.0 (river mile 20.7) than in fish from the other two locations. Cesium-137 concentrations in fish from CRK 8.0 and CRK 40 were not significantly different.

These statistical relationships are generally the same as for the 1990 data. The magnitudes of the averages are also not different between 1989 and 1990 for all six determinations in Table 5.2 at a confidence limit of 95%.

5.3 ORR DEER POPULATION

The sixth annual DOE-TWRA Managed Deer Hunts were held during the final quarter of 1990. Analytical Chemistry Division (ACD) personnel

Table 5.3. 1990 grass analyses at the K-25 Site[a]

Radionuclide	Number of samples	Concentration (μg/g dry wt)			
		Max	Min	Av	Standard error[b]
F^-	15	25	<3	<6.9	6.7
U	15	0.7	<0.5	<0.5	0.05
^{99}Tc	15	37.9[c]	–0.25	3.0	9.7

[a]See Fig. 5.3.
[b]Standard deviation about the average.
[c]Units are pCi/g instead of μg/g.

assisted by student members of the Wildlife Society (University of Tennessee chapter) performed most of the necessary operations at the checking station. The radiological surveillance of the harvest continues to be the responsibility of ACD personnel.

The basic conduct of the managed hunts for 1990 was similar to those of previous years; however, they consisted of one archery hunt (October 20–21) and two shotgun/muzzle-loader hunts (November 10–11 and December 8–9). During the archery hunt 151 deer were taken, and 291 were killed during the two gun hunts. From the total harvest of 442 animals, 239 (54%) were bucks and 203 (46%) were does. The 1990 harvest of 442 is similar to that of 1989, when 440 deer were taken. The heaviest buck had 12 antler points and weighed 191 lbs. The greatest number of points (13) were found on two bucks that weighed 151 lbs and 165 lbs, respectively. The heaviest doe weighed 117 lbs.

Soft tissue (liver or muscle) radioactivity concentrations of ^{137}Cs continued to be low and acceptable. Only two deer of the harvest exceeded 1.0 pCi/g (confiscation limit is 20 pCi/g). The maximum concentration of ^{137}Cs was 3.7 pCi/g. Strontium-90 concentrations in bone exceeded 30 pCi/g (confiscation limit) in 6 deer out of the 442 harvest (1.3%). The maximum ^{90}Sr concentration was 217 pCi/g.

5.4 VEGETATION

Contamination of growing plants may result from absorption of materials from soil or from deposition of materials from the atmosphere. Grass was analyzed routinely for fluorides by the K-25 Site because of its importance as pasture for dairy herds and its year-round availability. Grass also provides an early indication of fallout because of the relatively large surface area of the grass blades exposed to air.

Radioactivity measurements of grass samples were not conducted at ORNL in 1990. The grass program was assessed a low priority because grass samples from the ORR do not represent a direct pathway to man. Contamination of grass used for agricultural grazing is monitored through the milk program.

5.4.1 Sample collection and analytical procedures

Grass samples were collected at the K-25 Site from 15 locations, and pine needles were collected at 6 of these locations. These locations are shown in Fig. 5.3. About 0.45 kg (1 lb) of vegetation is picked and submitted for uranium, technetium, and fluoride analyses. Fluorometric analysis is used to determine concentrations of uranium, while a fluoride-selective ion electrode is used to determine the presence of fluorides. Table 5.3 gives a summary of the grass sampling data. Table 5.6 in Vol. 2 provides data on individual sampling locations. Sample location V-5 (PN-4) was not sampled because of road construction.

5.4.2 Results

K-25 Site

The results for the grass and pine needle samples are given in Table 5.6 in Vol. 2.

The fluoride levels in grass at all sampling points were below the 30-μg/g level, which is considered to produce adverse effects when ingested by cattle with average grazing intakes (AIHA 1969). Technetium

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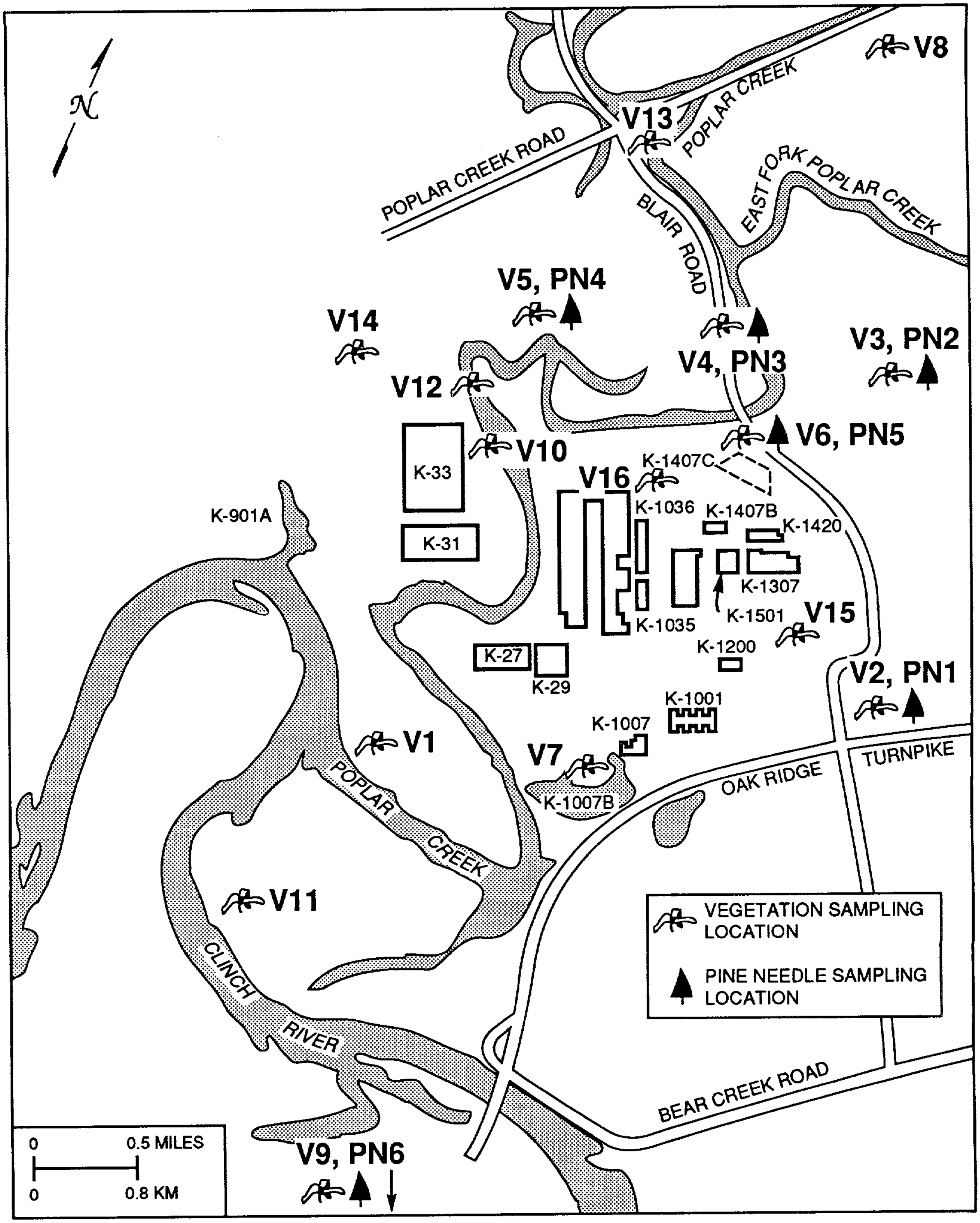

Fig. 5.3. Map of pine needle and grass sampling locations at the K-25 Site.

concentrations were highest at V11, the contaminated scrap yard. The uranium concentrations ranged from below detection to 0.7 μg/g (V11). The technetium concentration ranged from below detection to 37.9 pCi/g (V11).

SOIL AND SEDIMENT MONITORING

6. SOIL AND SEDIMENT MONITORING

6.1 SOIL

Soil samples from noncultivated areas provide a measure of the quantity of radioactivity or other pollutants that have been deposited from the atmosphere.

6.1.1 Oak Ridge National Laboratory and Y-12 Plant

Soil samples were collected at the ORNL and Y-12 perimeter air monitoring stations. Table 6.1 provides a summary of the locations sampled and the frequencies of sampling and analysis.

The concentrations of radionuclides in soil vary because of differences in rainfall patterns and the mechanics of transport in different types of soil. The rate of migration in soil also varies significantly from one radionuclide to another. For example, strontium tends to migrate through soil more freely than do cesium or plutonium. In addition, chemical separation of radionuclides such as strontium and plutonium from soil samples is complicated by the heterogeneity of the soil and the difficulty of stripping ions from the soil. Therefore, individual measurements may not be representative of large areas. Average concentrations of several samples provide a better measure of soil radionuclide concentrations. Thus, three samples are collected from each station annually.

Sample collection and analytical procedures

Soil samples were collected at the ORNL perimeter air monitoring stations and the Y-12 perimeter air monitoring stations once during 1990. The three samples collected at each location were randomly selected from the four cardinal directions at each of the stations. Each sample was a composite of ten aliquots taken from two 1-m^2 plots. Each aliquot was 8 cm (3.7 in.) in diameter by 2 cm (0.8 in.) deep. All samples were dried and pulverized prior to analysis.

This year the analytical parameter list was expanded to include a more comprehensive list of radionuclides and multi-element metals analysis conducted by IPC arc emission spectrometry.

Results

Summary concentrations of radionuclides in soils for each of the facility perimeters are presented in Table 6.2. All results are reported on a dry weight basis. Network summaries of the metals analyses are provided in Tables 6.1 and 6.2 in Vol. 2. Summary

Table 6.1. Summary of collection and analysis frequencies of soil sampling in 1990

Station[a]	Parameter	Collection frequency	Sample type	Analysis frequency
3, 7, 9, 20, 21, 40, 45, 46	Total Sr,[b] ^{239}Pu, gamma scan, ^{238}Pu, ^{234}U, ^{235}U, ^{238}U ICP metals	Annually	Grab	Annually

[a]See Fig. 2.19.
[b]Total radioactive strontium (^{89}Sr + ^{90}Sr).

Table 6.2. 1990 concentrations of radionuclides in soil at ORNL air stations

Analyte	Number of samples	Concentration (pCi/g dry wt)			
		Max	Min	Av[a]	Standard error[b]
		ORNL Perimeter Stations[c]			
^{60}Co	15	0.19	−0.11	0.031	0.020
^{137}Cs	15	3.2	0.11	1.4*	0.24
G-Alpha	15	13	3.2	6.7*	0.61
G-Beta	15	25	6.5	17*	1.3
^{40}K	15	21	3.2	11*	1.5
^{238}Pu	15	0.043	−0.043	0.00034	0.0056
^{239}Pu	15	0.089	−0.046	0.017	0.0098
^{228}Th	15	0.65	0.23	0.40*	0.034
^{230}Th	15	0.54	0.11	0.24*	0.030
^{232}Th	15	0.46	0.11	0.26*	0.025
Total-Sr	15	0.81	0.11	0.32*	0.049
^{234}U	15	1.2	0.32	0.55*	0.072
^{235}U	15	0.65	0.002	0.072	0.041
^{238}U	15	0.68	0.20	0.35*	0.041
		Oak Ridge Reservation Stations[c]			
^{7}Be	9	0.46	−0.38	0.075	0.099
^{60}Co	9	0.097	−0.027	0.040*	0.015
^{137}Cs	9	0.92	−0.0081	0.37*	0.093
G-Alpha	9	13	5.7	7.9*	0.77
G-Beta	9	30	5.4	15*	2.4
^{40}K	9	18	1.6	11*	1.9
^{238}Pu	9	0.013	−0.011	0.0038	0.0027
^{239}Pu	9	0.004	−0.016	−0.0032	0.0025
^{228}Th	9	0.68	0.21	0.45*	0.051
^{230}Th	9	0.38	0.13	0.24*	0.025
^{232}Th	9	0.30	0.070	0.21*	0.022
Total-Sr	9	0.65	−0.027	0.26*	0.070
^{234}U	9	5.9	1.5	3.3*	0.41
^{235}U	9	1.1	0.12	0.35*	0.10
^{238}U	9	3.0	0.59	1.5*	0.32

[a]An asterisk (*) indicates that the average is significantly greater than zero at the 95% level of confidence.

[b]Standard error of the mean.

[c]See Fig. 2.19.

concentrations of radionuclides, total radioactive strontium, and metals at each of the stations within each network are given in Tables 6.3 through 6.10 in Vol. 2. The data from 1989 and 1990 were compared using a t test at 95% confidence. There were no significant differences between the two years of data except for ^{137}Cs. The ^{137}Cs value for 1990 is higher than the 1989 value and not different from the 1988 value. This suggests that the 1989 average was anomalously low. The uranium concentrations around the Y-12 perimeter were higher than around the ORNL perimeter. This is typical for soil data from these locations. These data are similar in magnitude to the data from the remote stations from 1988, except for the elevated uranium values around Y-12. The additional radionuclide and metals data will be used to assess trends in soil concentrations commencing next year.

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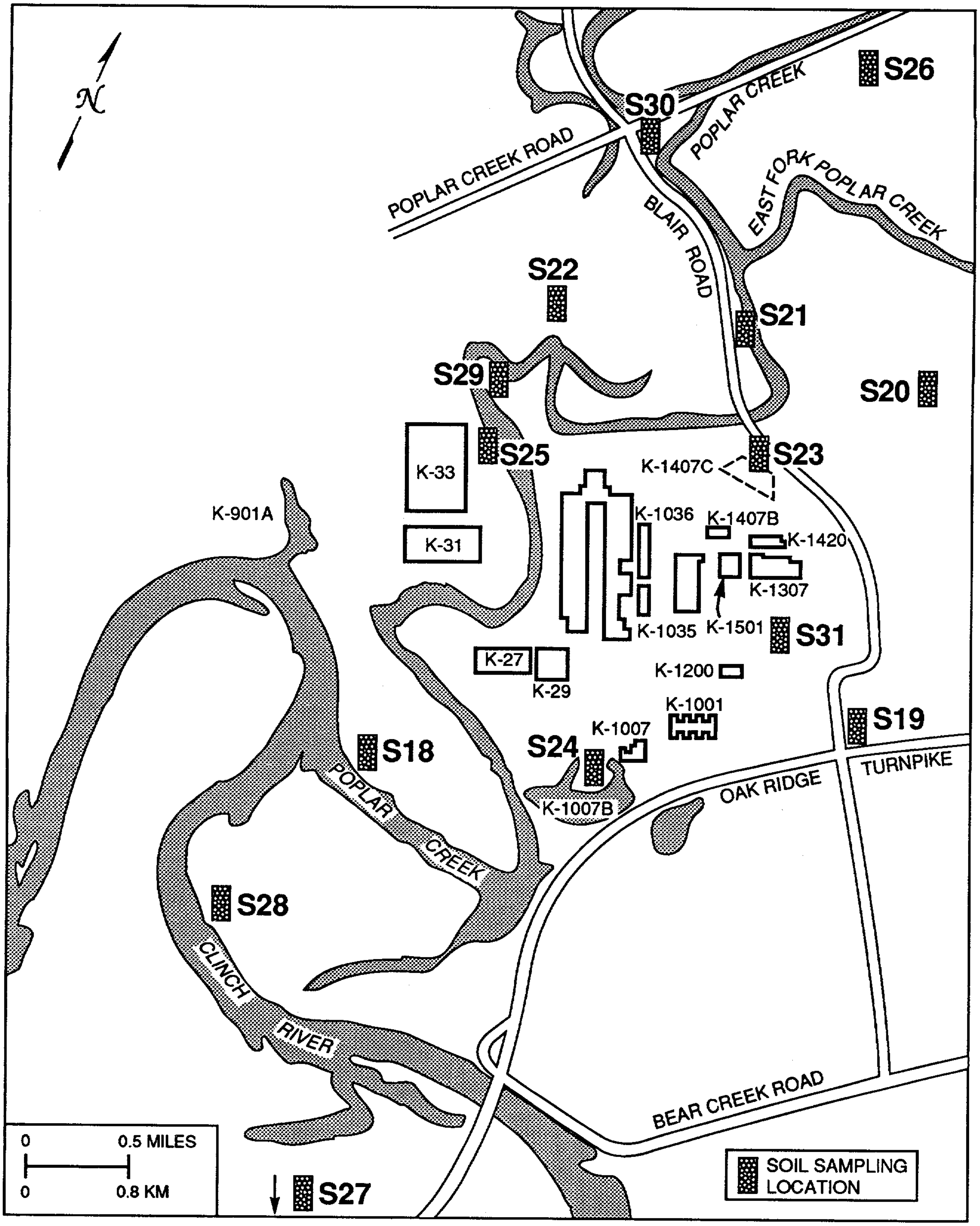

Fig. 6.1. Soil sampling locations around the K-25 Site.

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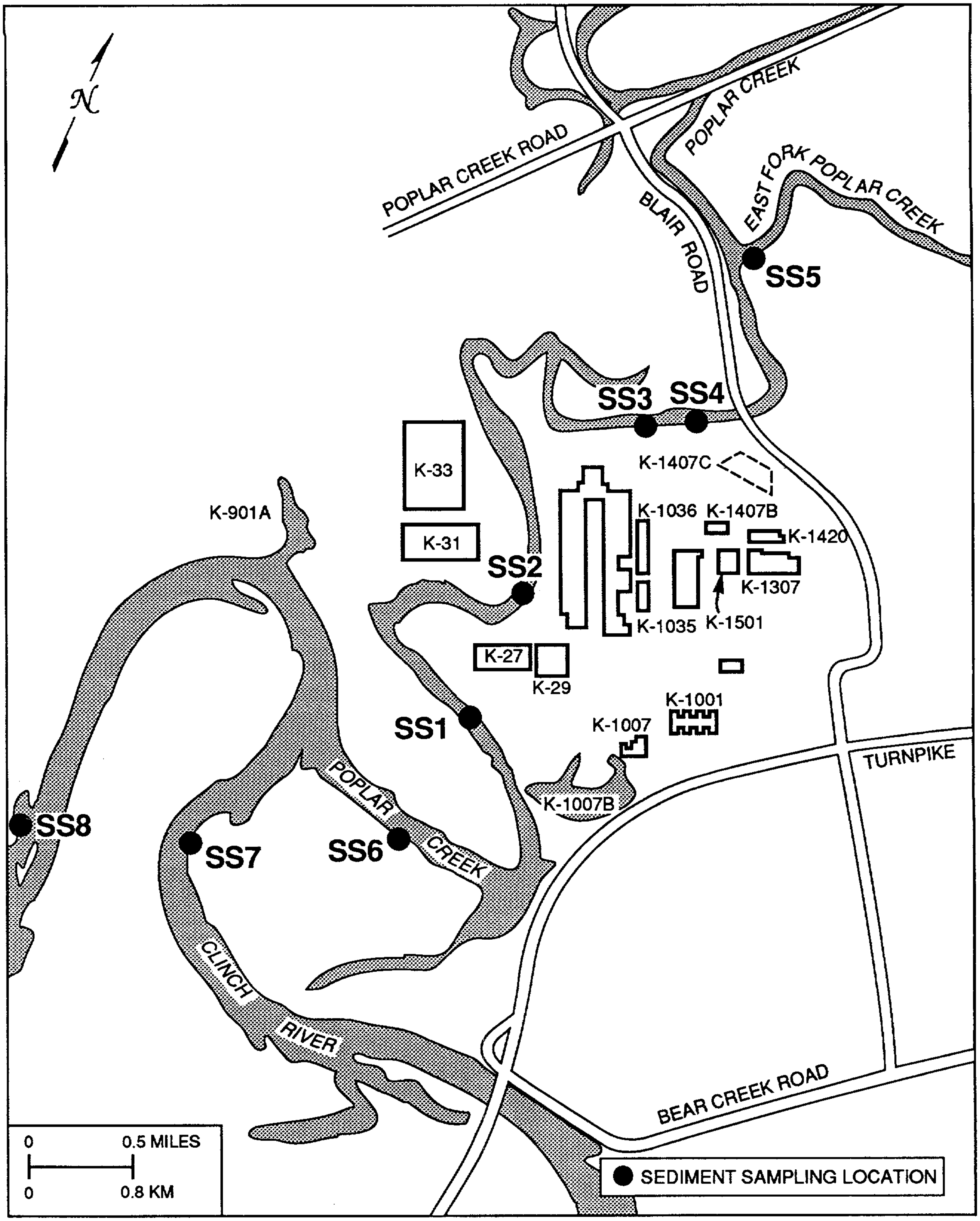


Fig. 6.2. Stream sediment sampling locations at the K-25 Site.

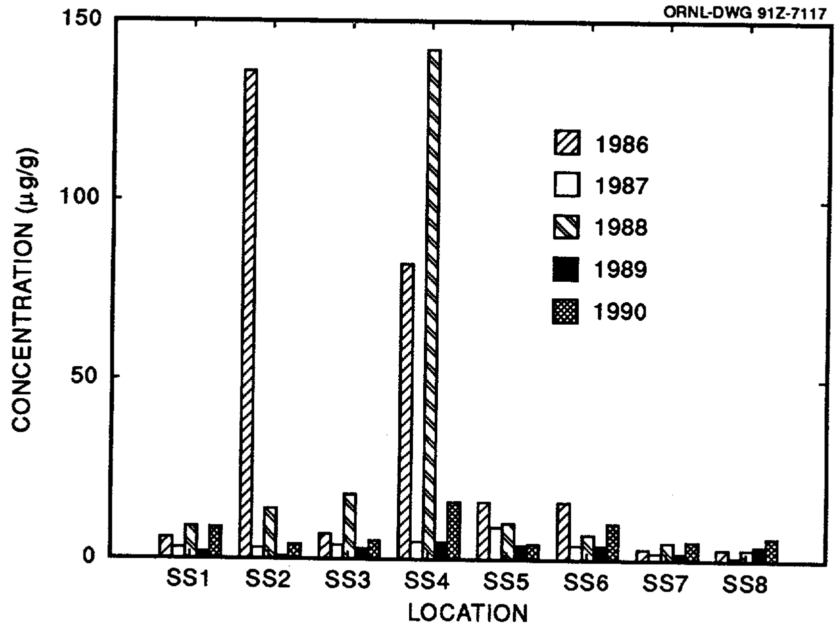


Fig. 6.3. Average uranium concentrations (µg/g dry weight) in sediment, 1986–1990.

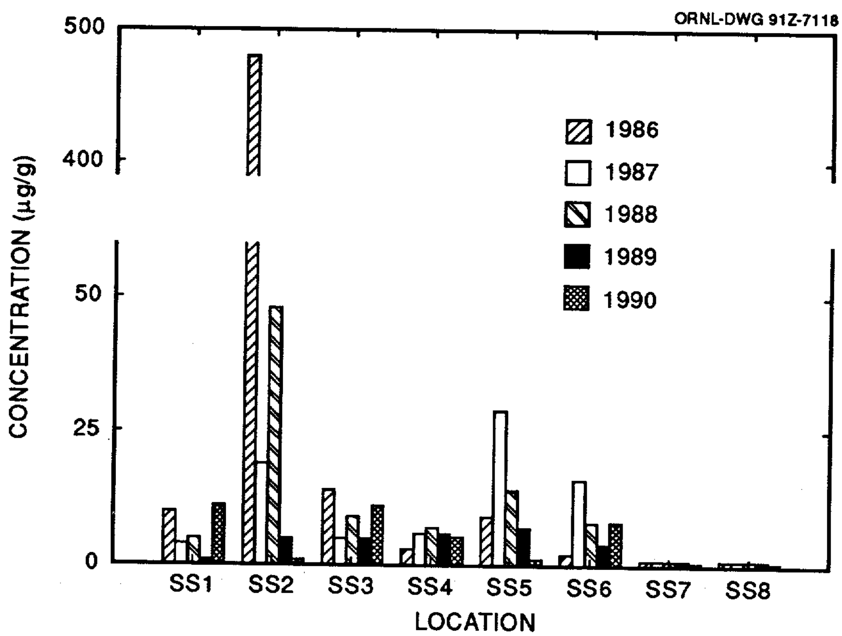


Fig. 6.4. Average mercury concentrations (µg/g dry weight) in sediment, 1986–1990.

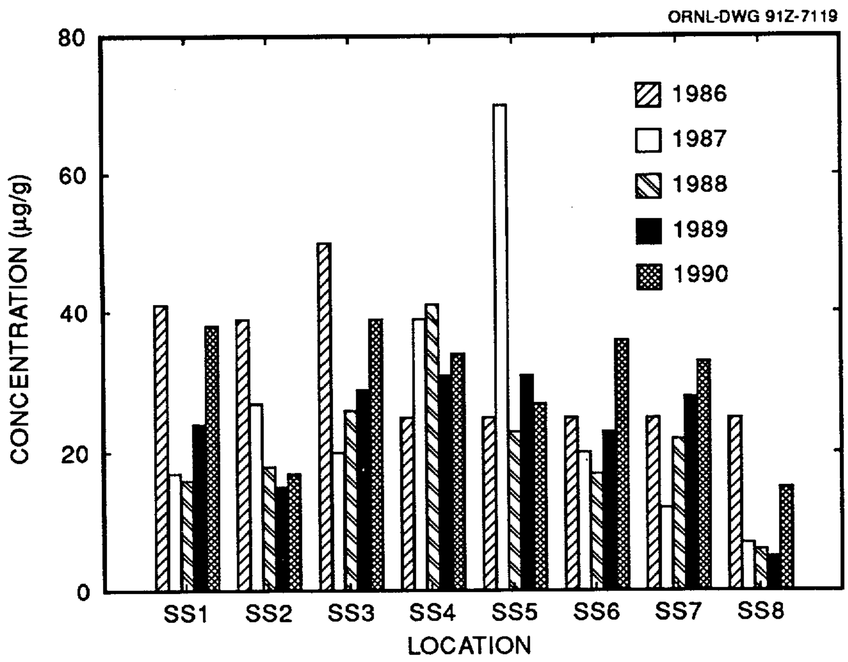


Fig. 6.5. Average lead concentrations (μg/g dry weight) in sediment, 1986–1990.

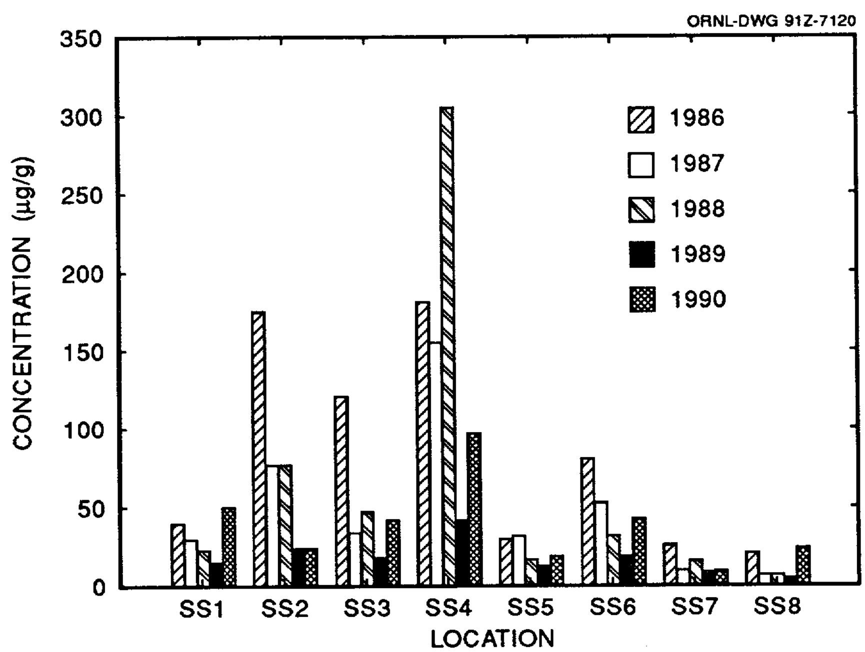


Fig. 6.6. Average nickel concentrations (μg/g dry weight) in sediment, 1986–1990.

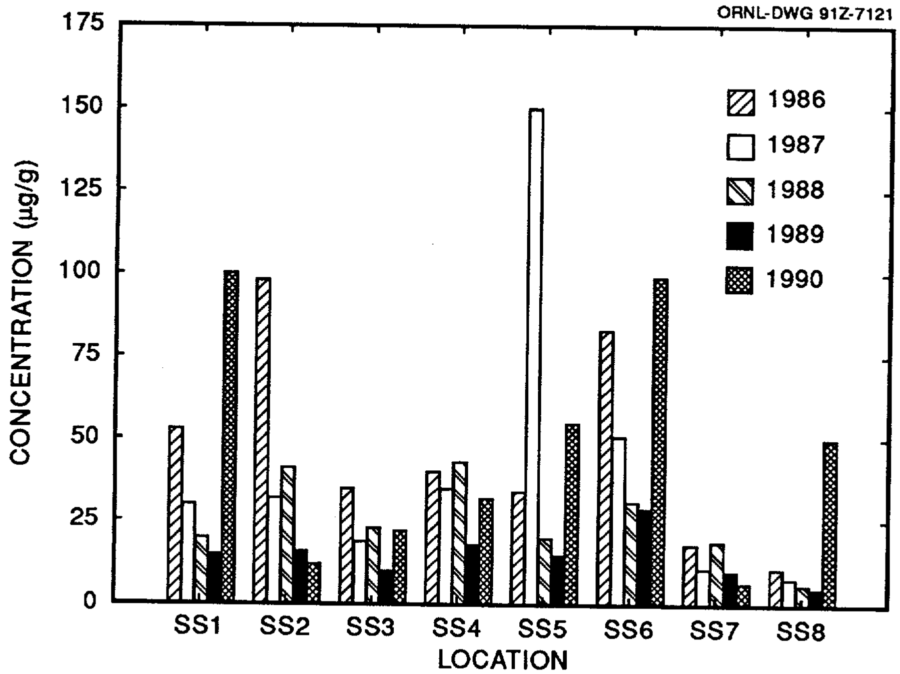


Fig. 6.7. Average chromium concentrations (μg/g dry weight) in sediment, 1986–1990.

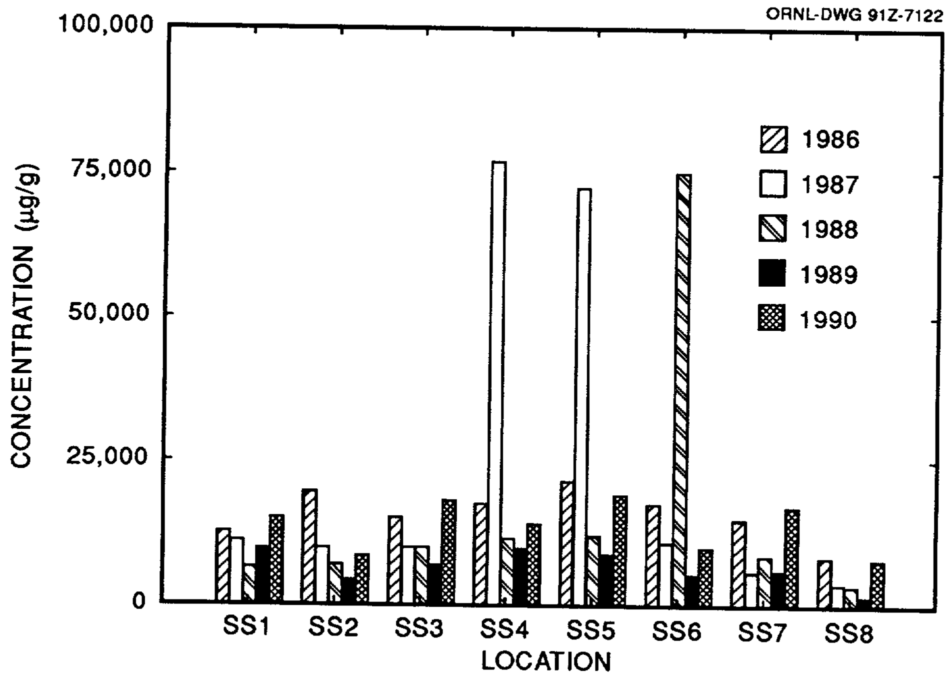


Fig. 6.8. Average aluminum concentrations (μg/g dry weight) in sediment, 1986–1990.

6.1.2 K-25 Site

Sample collection and analytical procedures

Samples were collected from 13 locations in and around the K-25 Site (Fig. 6.1). Site S22 was not sampled in 1990 because of road construction in the area.

Approximately 450 g of soil was collected using a stainless steel scoop to remove the top 1 cm (0.4 in.) of the sampling area. Fluorometric analysis was used to determine uranium levels, and a fluoride-selective-ion electrode was used to determine fluoride levels. This year samples were collected only once as opposed to semiannually as in the past. This is because of a recommendation from an assessment of the ambient environmental monitoring programs.

Results

The results of the sampling are given in Table 6.11, Vol. 2. The fluoride concentrations ranged from 48 μg/g at station S24 to 1251 μg/g at station S29. The concentration of fluoride in the soil is almost 100 times higher than that in grass. Uranium concentrations have not changed significantly since 1985. The concentration of uranium in the soil is generally 10 times the amount in grass. Sample S28, from the contaminated scrap yard, continues to have the highest concentration of uranium.

6.2 SEDIMENT

6.2.1 Sample collection and analytical procedures

The stream sediment sampling program consists of six sampling locations from Poplar Creek and two locations from the Clinch River (Fig. 6.2). These samples were collected in the summer and analyzed for concentrations of mercury, lead, nickel, copper, zinc, chromium, manganese, aluminum, thorium, cadmium, and total uranium by atomic absorption, inductively coupled plasma, and fluorometric methods. The surface samples are collected using a core sampler that is lowered over the side of a boat. Approximately 50 g of sediment is needed for the analyses.

6.2.2 Results

Table 6.12 in Vol. 2 gives data for the K-25 Site stream sediment samples. From 1985 to 1989, the concentrations of lead, nickel, copper, chromium, and aluminum decreased. In 1990, the concentration of these metals and uranium increased. Samples from SS7 and SS8 on the Clinch River continue to have the lowest concentrations of the sampling stations. Bar graphs indicating trends since 1986 are shown in Figs. 6.3–6.8 for six of the most prominent metals: uranium, mercury, lead, nickel, chromium, and aluminum.

POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC

7. POTENTIAL RADIATION AND CHEMICAL DOSE TO THE PUBLIC

7.1 RADIATION DOSE

Small quantities of radionuclides were released to the environment from operations at the ORR facilities during 1990. Those releases are quantified and characterized in Sects. 2 through 6. Section 7 presents estimates of the potential consequences of the releases and describes the methods used to make the estimates.

7.1.1 Terminology

Most consequences to humans associated with radionuclide releases to the environment are caused by interactions between radiations emitted by the radionuclides and human tissue. These interactions involve the transfer of energy from the radiations to tissue, a process that may damage the tissue. The radiations may come from radionuclides located outside the body (in or on environmental media or objects) or from radionuclides deposited inside the body (via inhalation, ingestion, and in a few cases, absorption through the skin). Exposures to radiations from nuclides located outside the body are called external exposures; exposures to radiations from nuclides deposited inside the body are called internal exposures. These two types of exposures differ as follows: (1) External exposures occur only when a person is near or in a radionuclide-containing medium; internal exposures continue as long as the radionuclides remain inside the person. (2) External exposures may result in uniform irradiation of the entire body and all its components; internal exposures usually result in nonuniform irradiation of the body. (Most radionuclides, when taken into the body, deposit preferentially in specific organs or tissue and thus do not irradiate the body uniformly.)

A number of specialized units have been defined for characterizing exposures to ionizing radiation. Because the damage associated with such exposures is due primarily to the deposition of radiant energy in tissue, the units are defined in terms of the amount of incident radiant energy absorbed by tissue and the biological consequences of the absorbed energy. Some of these units are as follows.

Absorbed dose. A physical quantity that defines the amount of incident radiant energy absorbed per unit mass of an irradiated material; its unit of measure is the rad. The absorbed dose depends on the type and energy of the incident radiation and on the atomic number of the absorbing material.

Dose equivalent. A quantity that expresses the biological effectiveness of an absorbed dose in a specified human organ or tissue; its unit of measure is the rem. The dose equivalent is numerically equal to the absorbed dose multiplied by modifying factors that relate the absorbed dose to biological effects. In this report, as in many others, the term "dose equivalent" often is shortened to "dose."

Effective dose equivalent (EDE). A risk-equivalent dose equivalent that can be used to estimate health-effects risks to exposed persons. It is a weighted sum of dose equivalents to specified organs. The weighting factors and specific organs are described in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP 1977; ICRP 1978).

Committed (effective) dose equivalent. The total (effective) dose equivalent that will be received over a specified time period (50 years in this document) because of exposures to, and intakes of, radionuclides during the year of interest.

Collective (committed) effective dose equivalent. The sum of (committed) effective dose equivalents to all individuals in an exposed population.

Dose conversion factor (DCF). The dose equivalent received from exposure to a unit quantity of a radionuclide via a specific exposure pathway. Two types of DCFs exist. One type gives the committed dose equivalent (rem) resulting from intake (via inhalation and ingestion) of a unit activity (1.0 μCi) of a radionuclide. The second gives the dose equivalent rate (mrem/year) per unit activity (1.0 μCi) of a radionuclide in a unit (cm^3 or cm^2) of an environmental compartment (air or ground surface). Table 7.1, Vol. 2, is a listing of DCFs for inhalation and ingestion of selected radionuclides released from the ORR; Table 7.2, Vol. 2, is a listing of DCFs for immersion in contaminated air and for exposure to a contaminated ground surface (Beres 1990). The radionuclides listed account essentially for all of the radiation doses from the ORR.

7.1.2 Methods of Evaluation

7.1.2.1 Airborne radionuclides

Characterization of the radiological consequences of radionuclides released to the atmosphere from ORR operations during 1990 was accomplished by calculating, for each plant and for the entire ORR, EDEs to the maximally exposed off-site individual and to the entire population residing within 80 km (50 miles) of the plants. The dose calculations were made using the CAP-88 package of computer codes (Beres 1990), which was developed under sponsorship of the EPA for use in demonstrating compliance with NESHAP—Radionuclides, 10 CFR Pt. 61. This package contains the most recent, approved version of the AIRDOS-EPA and DARTAB codes and ALLRAD88 radionuclide data file. The AIRDOS-EPA computer code implements a steady-state, Gaussian plume, atmospheric dispersion model to calculate concentrations of radionuclides in the air and on the ground, and uses Regulatory Guide 1.109 foodchain models to calculate radionuclide concentrations in foodstuffs (vegetables, meat, and milk) and subsequent intakes by man. The concentrations and human intakes are used by the EPA's latest version of the DARTAB computer code to calculate EDEs to man from radionuclides released to the atmosphere. The dose calculations use the DCFs contained in the ALLRAD88 data file (Tables 7.1 and 7.2 of Vol. 2).

Radionuclide release data were collected or estimated for eight release points at ORNL, for three release points at the K-25 Site, and for one combined release point at the Y-12 Plant. Table 7.1 lists the source parameter values used in the calculations. The radionuclide release inventory is detailed in Sect. 2 and summarized in Tables 7.3, 7.4, and 7.5 of Vol. 2, which are lists of the nuclides released, the quantity (Ci) released from each release point, and the particle size (AMAD) and solubility classes used in the calculations. The list of radionuclides used in the calculations for ORNL includes estimated (potential) releases due to miscellaneous sources (Table 7.3 in Vol. 2); these nuclides are not included in the monitored releases discussed in Sect. 2.

Meteorological data used in the calculations consisted of joint frequency (STAR) distributions of wind direction, wind speed class, and atmospheric stability category that were prepared from data collected during 1990 at the 100-m station on tower MT2 for ORNL, at the 60-m station on tower MT1 for the K-25 Site, and at the 30-m station on tower MT5 for the Y-12 Plant. Rainfall on Oak Ridge during 1990 was 152 cm, the average air temperature was 15°C, and the average mixing layer height was 1000 m.

The dose calculations assumed that each person remained, unprotected, at home (actually outside the house) during the entire year and obtained food according to the rural pattern defined in the NESHAP background documents (EPA 1989b). This pattern specifies that 70% of the vegetables and produce, 44.2% of the meat, and 39.9% of the milk consumed by each person are produced in the local area (e.g., a home garden). The remaining portion of each food is assumed to be produced within 80-km (50-mile) of the ORR. Use of this pattern is more conservative than the consumption patterns used in previous annual reports. For collective EDE estimates, production of beef, milk, and crops within the 80-km of the ORR were calculated using the state-specific production values provided with CAP-88.

Calculated EDEs due to radionuclides emitted to the atmosphere from the ORR are listed in Tables 7.2 (maximum individual) and 7.3 (collective). The EDE received by the hypothetical, maximally exposed individual for the ORR was calculated to be ~2 mrem, which is below the 10-mrem NESHAP limit and well below the ~300 mrem that the individual actually received from natural sources of radiation. This individual is located ~8760 m (5.4 miles) NE of the 3039 stack at ORNL, ~13,000 m (8.1 miles) ENE

Table 7.1. Release point parameters and receptor locations used in the dose calculations

Source name	Type	Release height (m)	Inner diameter (m)	Gas exit velocity (m/s)	Gas exit temperature (°C)	Distance (m) and direction to maximally exposed individual	
						Plant	ORR
			Y-12 Plant				
All	Point	20	0	0	Ambient	1080 NNE	1080 NNE
			ORNL				
2026	Point	22.9	1.1	11.4	Ambient	5450 E	8760 NE
3020	Point	61.0	1.5	11.5	Ambient	5450 E	8760 NE
3039	Point	76.2	2.4	16.6	Ambient	5450 E	8760 NE
7025	Point	4.0	0.3	14.0	Ambient	3500 E	7030 NNE
7512	Point	30.5	0.9	7.3	Ambient	4550 ENE	9120 NNE
7911	Point	76.2	1.5	10.1	Ambient	4550 ENE	9120 NNE
7830	Point	4.6	0.2	7.1	Ambient	5810 ENE	10440 NNE
Misc.	Point	15	0	0	Ambient	4970 SW	8760 NE
			K-25 Site				
K-1435	Point	30.5	1.37	4.63	68.9	5180 WSW	13000 ENE
K-1420	Point	12.8	0.35	19.8	Ambient	4820 WSW	13250 ENE
K-1015	Point	6.1	0	0	Ambient	4390 WSW	14000 ENE

Table 7.2. Calculated radiation doses to maximally exposed off-site individuals from airborne release during 1990

Plant	Total effective dose equivalents (mrem)	
	Plant	ORR
ORNL[a]	0.2	0.1
K-25 Site[b]	0.006	0.002
Y-12 Plant[c]	2	2
Entire ORR[d]		2

[a]The maximally exposed individual is located 5450 m (3.4 miles) E of the 3039 stack and 3500 m (2.2 miles) E of the 7025 stack.

[b]The maximally exposed individual is located 5180 m (3.2 miles) WSW of the K-1435 stack.

[c]The maximally exposed individual is located 1080 m (0.7 miles) NNE of the Y-12 Plant release point.

[d]The maximally exposed individual for the entire ORR is the Y-12 Plant maximum individual.

Table 7.3. Calculated collective 50-year committed effective dose equivalents due to airborne releases during 1990

Plant	50-year committed dose equivalents (person-rem)
ORNL[a]	4
K-25 Site[b]	0.2
Y-12[c]	20
ORR[d]	30

[a]The collective 50-year committed dose equivalents to the 933,000 persons residing within 80 km (50 miles) of the ORNL.
[b]The collective 50-year committed dose equivalents to the 907,757 persons residing within 80 km of the K-25 Site.
[c]The collective 50-year committed dose equivalents to the 943,000 persons residing within 80 km of the Y-12 Plant.
[d]The collective 50-year committed dose equivalents for the area within an 80-km radius of the ORR are the sums of the corresponding doses for each of the three plants.

Table 7.4. Potential 50-year committed dose equivalents from drinking water in 1990[a]

Location	Effective dose equivalents (mrem)
Melton Hill Dam	0.1
Gallaher process water	0.1
Kingston water plant	0.04

[a]Assumes ingestion of 730 L of water per year (2 L per day).

the K-1435 (TSCA) stack at K-25, and ~1080 m (0.7 miles) NNE of the Y-12 release point. The collective EDE to the entire population around the ORR (~950,000 persons) was ~30 person-rem, which is ~0.01% of the ~285,000 person-rem that this population received from natural sources of radiation.

The EDE received by the hypothetical, maximally exposed individual for ORNL was calculated to be ~0.2 mrem. This individual is located ~5450 m (3.4 miles) E of the 3039 stack and 3500 m (2.2 miles) E of the 7025 stack. Approximately 91% of this dose is due to ingestion and inhalation of ^{3}H. The 50-year committed collective EDE to the ~933,000 persons residing within 80 km of ORNL was calculated to be ~4 person-rem.

The EDE received by the hypothetical, maximally exposed individual for the K-25 Site was calculated to be ~0.006 mrem. This individual is located ~5180 m (3.2 miles) WSW of the K-1435 (TSCA) stack. Essentially all of this dose is due to ingestion and inhalation of uranium, primarily ^{234}U and ^{238}U. The 50-year committed collective EDE to the ~908,000 persons residing within 80 km of the K-25 Site was calculated to be ~0.2 person-rem.

The EDE received by the hypothetical, maximally exposed individual for the Y-12 Plant was calculated to be ~2 mrem. This individual is located ~1080 m (0.7 miles) NNE of the Y-12 release point. Essentially all of this dose is due to ingestion and inhalation of uranium, primarily ^{234}U and ^{238}U. The 50-year committed collective EDE to the ~943,000 persons residing within 80 km of the Y-12 Plant was calculated to be ~20 person-rem.

7.1.2.2 Waterborne radionuclides

Waterborne discharges of radionuclides from ORNL flow into White Oak Creek, through White Oak Lake, and discharge into the Clinch River. Discharges from the Y-12 Plant and from the K-25 Site enter the Clinch River via Bear Creek, Poplar Creek, and East Fork Poplar Creek. Concentrations of radionuclides in water are given in Table 3.8 for samples taken at the Melton Hill Dam, the K-25 process water intake (Gallaher), and the Kingston water plant. Committed dose equivalents to persons drinking these waters were calculated using annual-average concentrations of radionuclides that are significantly different from zero and the assumption that a person drinks 2 L (2.1 quarts) of water per day [730 L/year (193 gal/year)]. The resulting potential dose estimates are given in Table 7.4. The EDE estimated for consumption of water from Melton Hill Dam, 0.1 mrem, represents an upstream (background) dose. Uranium isotopes are the contributors to this dose. Water sampled at the inlet to the K-25 Site (Gallaher process water) is the closest nonpublic water supply downstream of ORNL discharges. The calculated EDE from drinking this water is 0.1 mrem and is due to ^{90}Sr, ^{3}H, ^{238}Pu, and ^{60}Co. The public water supply closest to the ORR is located about 26 km (15.6 miles) downstream, at Kingston. Based on measured concentrations of ^{90}Sr and ^{3}H in river water, a person drinking water from the intake of the Kingston filtration plant could receive an EDE of 0.04 mrem. This could result in a collective committed effective dose of about 0.3 person-rem to the estimated 7500 persons who could drink this water. Radionuclide concentrations are also measured in Bear Creek and East Fork Poplar Creek, which contain discharges from the Y-12 Plant and the K-25 Site. However, no one is known to drink water from these streams; therefore, dose estimates were not made for drinking water from these creeks.

Potential doses to individuals eating 21 kg (about 46 lb) of fish per year are given in Table 7.5. These doses were calculated using measured concentrations of radionuclides in fish harvested at three locations (Table 5.5, Vol. 2). The highest potential EDE, 0.3 mrem, could be received by eating fish from CRK 33.3, which is at the confluence of White Oak Creek and the Clinch River, ORNL's discharge point. Potential EDEs to persons eating fish taken upstream at Melton Hill Dam (CRK 40.0) and downstream at Kingston (CRK 8.0) are 0.01 and 0.05 mrem, respectively. The 0.05-mrem EDE to an individual from eating 21 kg of fish caught at Kingston could result in a population dose of about 0.4 person-rem if all of the inhabitants of Kingston each caught and ingested 21 kg of fish. The primary contributors to the EDE are ^{137}Cs at Kingston; ^{137}Cs, ^{90}Sr, and ^{60}Co at CRK 33.3; and ^{90}Sr and ^{137}Cs at Melton Hill Dam. To put these doses from waterborne radionuclides further into perspective, the nearest population (Kingston) exposed to these radionuclides would receive an annual collective committed EDE of about 0.7 person-rem from drinking water and eating fish. This represents about 0.03% of the annual dose from background radiation (2250 person-rem) to this population.

7.1.2.3 Radionuclides in other environmental media

One of the important pathways for movement of radionuclides from environmental media to man is the atmosphere→pasture→cow→milk food chain. Strontium-90 and ^{131}I are radionuclides that are especially important in this terrestrial food chain. The CAP-88 models calculated EDEs due to consumption of milk containing airborne radionuclides released from the ORR. Also, milk collected from area farms is sampled for radionuclides. Table 7.6 gives potential EDEs to an individual from drinking 310 L of sampled milk per year. Measured, annual-average concentrations of total radioactive strontium (assuming 100% ^{90}Sr) and ^{131}I in milk taken from sampling stations near the ORR (see Sect. 5.1, and Tables 5.1 and 5.2 in Vol. 2) were used to calculate

Table 7.5. Potential 50-year committed dose equivalents from eating fish in 1990[a]

Location	Effective dose equivalents (mrem)
CRK 8.0	0.05
CRK 33.3	0.3
CRK 40.0	0.01

[a]Assumes ingestion of 21 kg of fish per year.

Table 7.6. Potential 50-year committed dose equivalents from drinking milk in 1990[a]

Location[b]	Effective dose equivalents (mrem)
Immediate environs (stations 1, 2, 3, 4, 8)	Average 0.1 Range 0.07–0.2

[a]Assumes ingestion of 310 L of milk per year using the average radionuclide concentrations at each location.
[b]See Fig. 5.1.

the EDEs, which range from 0.07 to 0.2 mrem and average 0.1 mrem. Concentrations of ^{90}Sr and ^{131}I in sampled milk were extremely low (see Tables 5.1 and 5.2 in Vol. 2).

7.1.2.4 Direct radiation

External radiation exposure rates have been measured at a number of locations on and off the ORR. Most of this radiation is due to natural radioactivity in the ground. Table 7.7 gives postulated effective doses to individuals exposed, unshielded, to direct radiation at each monitoring station for 8760 h/year (24 h/d, all year). Doses due to background direct radiation over the state of Tennessee range from about 30 to 100 mrem/year and average 56 mrem/year (Myrick et al. 1981). The dose values given in Table 7.7 are within this range, with the exception of ORNL PAM Station 4, which was affected by plant operations, and historically predicted dose rates along the Clinch River at stations 64 through 67, located along the bank of the Clinch River between CRK 34 and 30. The latter elevated radiation levels are due to air-scattered gamma radiation from an experimental ^{137}Cs field located on the Reservation. It is extremely unlikely that an individual would be exposed to this gamma radiation for an entire year (8760 h). However, a hypothetical maximally exposed individual might spend 5 h/week

Table 7.7. Potential radiation dose equivalents from external exposures at locations on and off the ORR

Station	Effective dose equivalents (mrem/year)[a]
ORNL PAM	
03	28
07	50
20	68
ORR PAM stations	
08	85
31	61
33	55
34	62
36	56
40	65
41	42
42	55
43	55
44	51
45	55
46	71
Clinch River stations[b]	
60	52
61	88
64	160
65	180
66	210
67	105
68	88
69	46
Background[c]	
Average if 12 locations in Tennessee	56

[a]Assumes an exposure of 8760 h/year.
[b]*Source: Environmental Surveillance of the U.S. Department of Energy Oak Ridge Reservation and Surrounding Environs during 1987*, ES/ESH-4/V1 (1988).
[c]*Source*: Myrick, T. E., B. A. Bervin, and F. F. Haywood, *State Background Radiation Levels*, ORNL/TM-7343 (1981).

fishing along the shore. This individual could receive an effective dose equivalent of 6 mrem from a 250-h exposure to the average of the measured exposure rates at stations 65 and 66.

7.1.3 Doses to Aquatic Biota

DOE Order 5400.5, Chap. II, sets an absorbed dose rate limit of 1 rad/day to native aquatic organisms. To demonstrate compliance with this limit, absorbed dose rates to aquatic invertebrates, fish, and muskrats were calculated by multiplying measured radionuclide concentrations in surface waters on and around the ORR (Tables 3.1, 3.2, 3.8, and 3.10) and internationally recognized, organism-specific dose factors (National Research Council of Canada 1983). The results of these calculations, which are presented in Table 7.8, indicate that no aquatic biota should receive an absorbed dose at a rate greater than 1 rad/day. The highest potential dose rates were 0.05 rad/day to invertebrates, 0.005 rad/day to fish in Upper Bear Creek (km 12.4), and 0.05 rad/day to muskrats using Melton Branch.

7.1.4 Current-Year Summary

A summary of the maximum EDEs to individuals via several pathways of exposure is given in Table 7.9. It is unlikely (if not impossible) that any real person can be irradiated by all of these sources and pathways for a period of one year. However, if the nearest resident to the Y-12 Plant, who could receive an effective dose of 2 mrem from gaseous effluents, also drank milk from the sampled stations (0.1 mrem), ate fish from CRK 33 (0.3 mrem), and fished the Clinch River between CRK 33 and 30 (6 mrem), he or she could receive a total EDE of about 8 mrem, or about 3% of the annual dose from background radiation.

DOE Order 5400.5 limits to no more than 100 mrem the effective dose equivalent that an individual may receive from all exposure pathways from all radionuclides released from the ORR during one year. As described above, the 1990 EDE, 8 mrem, was 8% of the DOE Order 5400.5 limit.

7.1.5 Five-Year Trends

Dose equivalents associated with selected exposure pathways for the years 1986 through 1990 are given in Table 7.10. The variation in values over this 5-year period is probably not statistically significant. The slight increases in effective doses from consumption of milk and water during 1987 probably are not real because the calculations are based on "less than" values of radionuclide concentrations, and the "less than" values reported for 1987 are higher than the "less than" values

Table 7.8. Potential dose rates to aquatic biota

Location	Absorbed dose rate (rad/day)		
	Invertebrates	Fish	Muskrats
Upper Bear Creek, km 11.97	0.02	0.002	0.0003
Upper Bear Creek, km 12.4	0.05	0.005	0.0008
Melton Branch 1	0.02	0.001	0.05
White Oak Creek	0.008	0.002	0.02
White Oak Dam	0.01	0.001	0.03
Melton Hill Dam	0.0004	0.0001	0.0004
Gallaher	0.001	0.0001	0.0001
Kingston	0.0003	0.00003	0.00003

Table 7.9. Summary of estimated radiation dose equivalents to an adult during 1990 at locations of maximum exposure

Pathway	Location	Effective (mrem)
Gaseous effluents	Nearest resident:	
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	2
	ORNL	0.2
	K-25 Site	0.006
	ORR	2
Terrestial food chain (milk)	Average of sampling stations	0.1
Liquid effluents		
Drinking water	Kingston	0.04
Eating fish	CRK 33 (ORNL discharge point)	0.3
Direct radiation	Clinch River shoreline (33.3 to 30.0 CRK)	6 (250 h/year)

reported for 1986. For drinking water during 1990, exclusion of radionuclides previously reported as being present at "less than" concentrations, but not really present, results in a dose estimate that is lower than those previously reported.

7.1.6 Findings and Conclusions

The maximally exposed off-site individual due to airborne effluents from the ORR could receive a 50-year committed EDE of ~2 mrem. This dose is within the limit specified in the Clean Air Act for DOE facilities. The estimated collective committed EDE to the approximately 9.4×10^5 persons living within 80 km (50 miles) of the ORR is ~30 person-rem for 1990 airborne emissions. This represents about 0.01% of the 2.8×10^5 person-rem the surrounding population would receive from all sources of natural radiation.

7.2 CHEMICAL DOSE

Varying amounts of chemicals were released to the environment from operations at ORR facilities during 1990. These releases are characterized and quantified in Sect. 3. In this section, estimates of potential human exposure to these chemicals are made, and the exposures are compared with acceptable levels of exposure as defined by federal standards and regulations.

Chemicals enter the body by several routes of intake including inhalation of air and dust, ingestion of food and water, and dermal absorption. Analysis of potential exposure through inhalation is not possible

Table 7.10. Five-year trends in committed effective dose equivalent for selected pathways

Pathway	Effective dose equivalent (mrem)				
	1986	1987	1988	1989	1990
Inhalation	4[a]	2	0.7	1	2
Milk consumption	0.1	<0.3	0.3	0.1	0.1
Fish consumption	0.8	0.3	0.2	0.2	0.3
Drinking water (Kingston)	0.1	<0.5	0.1	<0.3	0.04
Direct irradiation	9	6	6	6	6

[a]These are corrected values that were incorrectly reported in the 1986 report. In 1986, 0.13 Ci of enriched uranium and 0.06 Ci of depleted uranium were released from the Y-12 Plant. The depleted uranium was not included in the airborne dose calculations.

because of lack of environmental monitoring data. Potential exposure through dermal contact is considered to be unlikely for members of the general public because the sites are restricted areas.

The environmental monitoring data on surface water allow an analysis of the ingestion pathway via drinking water. Data on selected chemicals in fish allow an analysis of exposure via ingestion of food. Therefore, the exposure of humans to chemicals via drinking water and to selected chemicals via ingestion of food is provided.

7.2.1 Terminology

Definitions of terms pertinent to the understanding of exposure follow.

Acceptable Daily Intake (ADI). Intake of a chemical, measured in mg/day, that is not anticipated to result in an adverse health effect over a lifetime of exposure. ADIs are calculated from several different federal standards and regulations.

Calculated Daily Intake (CDI). Intake of a chemical, expressed in mg/day. For drinking water, it is assumed that adults drink 2 L of water per day.

Slope Factor (SF). An estimate based on a lifetime probability that a chemical will cause cancer at a dose of 1 mg/kg/day.

Maximum Contaminant Level (MCL). EPA National Interim Primary and National Primary Drinking Water Regulations that apply to all community or public water systems.

Reference Dose (RfD). An estimate of the daily exposure to the human population, including sensitive individuals, that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Secondary Maximum Contaminant Level (SMCL). EPA National Secondary Drinking Water Regulations that apply to public water systems.

7.2.2 Methods of Evaluation

7.2.2.1 Airborne chemicals

The release of chemicals into the air at ORR facilities is discussed in an earlier section. Air permits issued by TDC allow release of permitted quantities of chemicals. Sampling or monitoring is required only at the ORNL steam plant. No air-monitoring data amenable to human exposure analysis were available.

7.2.2.2 Waterborne chemicals

EPA has set daily intake standards for chemicals in the form of oral RfDs and SFs. These values are available from EPA's Integrated Risk Information System (IRIS) (EPA 1991). For noncarcinogenic chemicals, daily exposure to the RfD, in mg/kg/day, should result in no adverse effect over a lifetime. ADIs in mg/day were calculated from RfDs by multiplying by 70 kg, the average human body weight.

For carcinogens, ADIs were calculated from SFs using the formula:

$$ADI = \frac{1 \times 10^{-5} \times BW}{SF} ,$$

where

BW = 70 kg and
SF = a slope factor of risk per unit dose (risk per mg/kg/day).

A 1 in 100,000 (1^{-5}) lifetime risk of developing cancer was used in calculating the ADI.

For chemicals for which RfDs and SFs were not available, national primary and secondary drinking water regulations, in mg/L, were converted to ADI values by multiplying by 2 L, the average daily adult water intake.

Acceptable daily intakes for chemicals found in surface water at concentrations above detection limits are listed in Table 7.11. For RfDs and SFs, it is assumed that water ingestion is the only pathway of exposure.

Calculated daily intakes based on concentrations of chemicals found above detection limits at the three ORR sites and off-site are listed in Tables 7.12 through 7.15. Average values of the sampling data (in mg/L) were multiplied by 2 L to estimate daily intake levels. Much of the sampling data for individual chemicals were reported as "less than" (<) values indicating that concentrations were below the limit of detection of the instruments used. These data were used in the analysis only if one or more samples had values above the detection limit. Since average sample concentrations were reported as < values, the CDIs are also reported as < values. The CDIs were compared with the ADIs to establish whether the ingestion of 2 L of water would result in an exposure above the ADI. CDI/ADI ratios of <1 indicate an acceptable level of risk, while CDI/ADI ratios >1 indicate an unacceptable risk or the need for further study. Where CDIs are expressed as < values, CDI/ADI ratios are also expressed as < values, and the exposure cannot be fully quantified.

Sampling data for only inorganic chemicals were available for the two reference sites, Melton Hill Dam and White Oak Creek headwaters (Table 7.12). These sampling locations present background concentrations before the influence of the ORNL site and are useful for identifying the nonsite-related levels of chemicals. All CDI/ADI ratios were <1 or could not be quantified for the following reasons. The high concentrations of some inorganic chemicals such as aluminum, iron, and lead in the reference and monitoring samples and antimony in the reference samples are a reflection of the turbidity and high suspended solids (up to 340 mg/L) in the samples. Antimony is normally below the limit of detection when analysis is by ICP, and the one positive sample out of 12 samples at both reference sites may be due to a false positive. The high concentration of phosphorus at Melton Hill Dam but not in the White Oak Creek headwaters probably indicates the use of phosphate fertilizers in this area. Because analyses were for total phosphorus, a distinction between the potentially toxic element and phosphates could not be made, and phosphorus was not further considered. Nitrates are probably also high as a result of surface-water runoff from treated fields. In addition, chemicals such as iron that are essential human nutrients, that are present at concentrations only slightly elevated above naturally occurring levels, and that are toxic only at very high doses are usually not considered in risk assessments (EPA 1989b).

Sampling data for inorganic chemicals and total volatile organic chemicals were available for three Y-12 Plant monitoring stations (Table 7.13). Since volatile organic chemicals were not individually identified, intake for individual chemicals could not be assessed. Aluminum, iron, lead, phosphorus, and nitrate had CDI/ADI ratios >1 for the reasons explained above.

At White Oak Creek dam on the ORNL site (discharge point X15), CDIs for inorganic chemicals (Table 7.14) were similar to those for the White Oak Creek headwaters.

CDIs for surface water at monitoring locations upstream (West Fork Poplar Creek) and downstream (Clinch River) of the K-25 Site indicate little change in the number or concentrations of inorganic chemicals. CDI/ADI ratios for these perimeter locations were all <1 (Table 7.15). Analyses were performed for more than 80 organic chemicals, but concentrations were below the limits of detection, which were 0.005 to 0.01 mg/L for most chemicals. Data on aluminum and iron for comparison with the K-25 Site on-site monitoring data were not available for these two sites.

CDIs for four surface water monitoring stations at the K-25 Site were similar to those of other sites (Table 7.15). Of the more than 80 organic chemicals for which analyses were performed, the only ones found above the limits of detection were methylene

Table 7.11. Acceptable daily intakes for chemicals found above detection limits at ORR facilities

Chemical	ADI (mg/day)	Reference
Aluminum	0.1	SMCL[a]
Ammonia	64	RfD
Antimony	0.028	RfD
Arsenic	0.07	RfD
Barium	4.9	RfD
bis(2-ethylhexyl)phthalate	0.05	SF
Boron	6.3	RfD
Cadmium	0.035	RfD
Chloroform	0.1148	SF
Chromium	0.35	RfD
Copper	2.6	MCL[b]
Cyanide	0.02	RfD
Fluoride	4.2	RfD
Iron	0.6	SMCL
Lead	0.01	MCL
Manganese	7.0	RfD
Mercury	0.021	RfD
Methylene chloride	0.09	SF
Molybdenum	7.0	RfD
Nickel	1.4	RfD
Nitrate	70	RfD
Phenol	42	RfD
Phosphorus	0.0014	RfD
Selenium	0.21	RfD
Silver	0.21	RfD
Sulfate	800	MCL
Vanadium	0.49	RfD
Zinc	14	RfD

[a]SMCLs apply to all public water systems.

[b]MCLs apply to all public water systems (copper, sulfate) or to community water systems (lead).

Table 7.12. Chemical dose/acceptable daily intake comparisons for surface waters at ORR reference locations—annual 1990 average values

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
	Melton Hill Dam		
Aluminum	<1.36	0.1	<13.6
Antimony	<0.104	0.028	<3.71
Barium	<0.68	4.9	<0.014
Iron	<1.18	0.6	<1.97
Lead	<0.094	0.01	<9.4
Manganese	0.3	7.0	0.043
Phosphorus	<0.86	0.0014	<614
Selenium	<0.96	0.21	<0.457
Sulfate	22	800	0.028
Vanadium	<0.006	0.49	<0.012
	White Oak Creek Headwaters		
Aluminum	<1.4	0.1	<14
Antimony	<0.104	0.028	<3.71
Barium	<0.12	4.9	<0.024
Iron	<1.54	0.6	<2.57
Lead	<0.094	0.01	<9.4
Manganese	<0.24	7	<0.003
Nitrate	<10.2	70	<0.146
Vanadium	<0.0062	0.049	<0.127

[a]Values based on annual average sampling values.

Table 7.13. Chemical dose/acceptable daily intake comparisons for surface waters at Y-12 locations—annual 1990 average values

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
Upper Bear Creek (km 12.4)			
Aluminum	<0.82	0.1	<8.2
Barium	0.1528	4.9	0.031
Boron	0.126	6.3	0.02
Cadmium	<0.0026	0.035	<0.074
Chromium	<0.004	0.35	<0.011
Copper	<0.006	2.6	<0.002
Cyanide	<0.01	0.02	<0.5
Iron	<0.6	0.6	<1
Manganese	0.146	7.0	0.021
Mercury	<0.0006	0.021	<0.029
Molybdenum	<0.12	7.0	<0.017
Nickel	<0.024	1.4	<0.017
Nitrate	62.8	70	0.897
Phenols	<0.004	42	<0.0001
Phosphorus	<0.24	0.0014	<171
Silver	<0.01	0.21	<0.048
Vanadium	<0.008	0.49	<0.016
Zinc	<0.026	14	<0.002
Upper Bear Creek (km 11.97)			
Aluminum	<1.08	0.1	<10.8
Barium	0.962	4.9	0.196
Boron	0.1	6.3	0.016
Cadmium	<0.0128	0.035	<0.366
Chromium	<0.0088	0.35	<0.025
Cyanide	<0.012	0.02	0.6
Iron	0.78	0.6	1.3
Manganese	3.452	7.0	0.493
Mercury	<0.0004	0.021	<0.019
Nickel	0.088	1.4	0.063
Nitrate	300	70	4.29
Phenols	<0.004	42	<0.0001
Phosphorus	<0.22	0.0014	<157
Vanadium	<0.008	0.49	<0.016
Zinc	<0.020	14	<0.001
East Fork Poplar Creek: Station 17			
Cadmium	<0.0014	0.035	<0.04
Chloride	44.6	500	0.089
Copper	<0.016	2.6	<0.006
Fluoride	1.98	4.2	0.471
Lead	<0.040	0.01	<4
Mercury	0.0034	0.021	0.162
Molybdenum	<0.084	7.0	<0.012
Nickel	<0.020	1.4	<0.014
Nitrate	9.6	70	0.137
Phosphorus	0.66	0.0014	471
Sulfate	184	800	0.23
Zinc	0.11	14	0.008

[a]Values based on annual average sampling values.

Table 7.14. Chemical dose/acceptable daily intake comparisons for surface waters at ORNL locations—annual 1990 average values

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
Discharge Point: X15			
Aluminum	1.04	0.1	10.4
Ammonia	0.15	64	0.002
Arsenic	0.072	0.07	1.03
Chloroform	0.008[b]	0.1148	0.070
Chromium	0.026	0.35	0.074
Copper	<0.015	2.6	<0.006
Fluoride	<2	4.2	<0.476
Iron	1.18	0.6	0.197
Manganese	<0.176	7	<0.025
Mercury	<0.0001	0.021	<0.005
Nitrate	<10	70	<0.143
Phosphorus	0.80	0.0014	571
Sulfate	80	800	0.1
Zinc	0.042	14	0.003

[a]Values based on annual average sampling values.
[b]Estimated.

Table 7.15. Chemical dose/acceptable daily intake comparisons for surface waters at K-25 perimeter and on-site monitoring locations—annual 1990 average values

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
West Fork Poplar Creek			
Chromium	0.024	0.35	0.069
Manganese	0.286	7.0	0.041
Nickel	<0.022	1.4	0.016
Nitrate	0.6	70	0.009
Sulfate	37	800	0.046
Zinc	<0.008	14	0.0006
Clinch River			
Ammonia	0.6	64	0.009
Chromium	0.036	0.35	0.103
Copper	<0.008	2.6	0.003
Manganese	0.098	7.0	0.014
Nickel	0.024	1.4	0.017
Nitrate	0.65	70	0.009
Sulfate	39.5	800	0.049
Zinc	0.004	14	0.003
Monitoring Station K-716			
Aluminum	10.8	0.1	108
Ammonia	0.418	64	0.0065
Barium	0.118	4.9	0.024
Boron	0.016	6.3	0.003
Chromium	<0.024	0.35	<0.069
Copper	<0.20	2.6	<0.077
Fluoride	16.954	4.2	4.04
Iron	11.4	0.6	19
Lead	<0.008	0.01	<0.8
Manganese	0.214	7.0	0.031
Mercury	<0.0032	0.021	<0.152
Methylene chloride	0.00795	0.09	0.088
Nitrate	1.18	70	0.017
Sulfate	50	800	0.063
Zinc	<0.03	14	0.002
bis(2-ethylhexyl)phthalate	0.066	0.05	1.32
Monitoring Station K-1513			
Aluminum	0.4	0.1	4
Barium	0.056	4.9	0.011
Copper	0.008	2.6	0.003
Fluoride	0.20	4.2	0.048
Iron	0.44	0.6	0.733
Manganese	0.062	7.0	0.009
Nickel	0.04	1.4	0.029
Nitrate	0.80	70	0.011
Sulfate	40.0	800	0.050
Zinc	0.016	14	0.001
bis(2-ethylhexyl)phthalate	<0.03	0.05	0.6

Table 7.15 (continues)

Chemical	CDI[a] (mg/day)	ADI (mg/day)	CDI/ADI
Monitoring Station K-1710			
Ammonia	0.412	64	0.006
Chromium	0.020	0.35	0.057
Copper	<0.008	2.6	<0.003
Fluoride	0.538	4.2	0.128
Lead	<0.008	0.01	<0.8
Manganese	0.258	7.0	0.037
Nitrate	2.18	70	0.031
Sulfate	66.8	800	0.084
Zinc	<0.024	14	<0.002
bis(2-ethylhexyl)phthalate	0.040	0.05	0.8
Monitoring Station K-1770			
Aluminum	1.08	0.1	10.8
Barium	0.066	4.9	0.013
Boron	0.046	6.3	0.007
Chloride	7.4	500	0.015
Chromium	0.020	0.35	0.057
Copper	0.008	2.6	0.003
Cyanide	<0.182	0.02	<9.1
Fluoride	0.2	4.2	0.048
Iron	1.32	0.6	2.2
Manganese	0.070	7.0	0.01
Nickel	0.04	1.4	0.029
Nitrate	0.916	70	0.013
Sulfate	41.66	800	0.052
Zinc	0.016	14	0.001
bis(2-ethylhexyl)phthalate	<0.08	0.05	<1.6
Monitoring Station Mitchell Branch			
Ammonia	<0.04	34	<0.001
Chromium	0.020	0.35	0.057
Manganese	0.18	7.0	0.026
Sulfate	6.4	800	0.008
Zinc	<0.004	14	<0.0003
bis(2-exthylhexyl)phthalate	<0.08	0.05	<1.6

[a]Values based on annual average sampling data.

chloride (one location) and bis(2-ethylhexyl)-phthalate. The latter compound was found at all four stations on-site but not at the perimeter sampling stations. In addition to bis(2-ethylhexyl)phthalate, CDI/ADIs for fluoride and cyanide were also >1 at one on-site station.

Chemicals in water can be accumulated by aquatic organisms that may be eaten by humans. Mercury and PCB concentrations were measured in Clinch River bluegill sunfish. The highest concentration of mercury in bluegill, <0.19 mg/kg wet weight, was found at CRK 8.0. Assuming the average person eats 21 kg of fish per year (0.058 kg/day), the average daily intake of mercury would be 0.011 mg/day. This results in a CDI/ADI (0.011/0.021) of 0.5. Calculated average intake by ingestion of both fish and water, at the highest concentrations measured, results in a CDI of 0.0144 mg/day (0.011 mg/day + 0.0034 mg/day) and a CDI/ADI ratio of 0.68, indicating an acceptable level of ingestion.

PCBs were measured in bluegill sunfish taken at three sites on the Clinch River. All concentrations were below the maximum limit of detection, and daily intakes could not be quantified. At the Y-12 Plant, the only site at which PCBs were monitored, concentrations were below the level of detection.

In reality, surface water monitoring stations are generally located within areas of DOE facilities that are not readily accessible to the general public. Thus, consumption of water from these points is unlikely. Furthermore, as the pollutant moves downstream and the volume of water increases, the concentration of pollutant decreases.

7.2.2.3 Chemicals in other environmental media

An important pathway of concern for human exposure to chemicals is through atmospheric deposition onto vegetation and subsequent transfer into beef and milk. Direct measurements for concentrations of chemicals in vegetation, beef, or milk in the vicinity of ORR facilities have not been made.

7.2.2.4 Direct exposure

Direct exposure to chemicals does not represent a likely pathway of exposure at the ORR facilities. For airborne releases, concentrations off-site are too small to be a problem through the dermal exposure pathway. For aquatic releases, outfalls are generally located within areas of DOE facilities that are not readily accessible to the general public. Although exposures for consumption of drinking water at the monitoring stations were calculated, public consumption of water from the outfalls or at the monitoring stations is highly unlikely.

7.2.2.5 Current year summary

Additional information on routes of exposure other than surface waters is needed to achieve a more complete chemical exposure analysis. In the present analysis on exposure to waterborne inorganic chemicals, the majority of CDI/ADI ratios on-site were <1, indicating that for drinking water, most chemicals were below acceptable daily intake levels. Off-site exposures would be lower owing to stream dilution. Most organic chemicals were below the limit of analytical detection and should pose no risk to the public.

SOLID WASTE MANAGEMENT PROGRAM

8. SOLID WASTE MANAGEMENT PROGRAM

8.1 DESCRIPTION

8.1.1 Purpose

The goal of the solid waste management program is to handle solid wastes according to procedures that protect the health and safety of on-site personnel and the public, protect the environment, and minimize long-term liability. To meet this goal, the potential for environmental release of wastes must be minimized. Hence, solid waste management activities are conducted in compliance with state and federal regulations and conform to good industry practices, which in some cases are more protective than the practices mandated by the regulations.

The solid waste management program encompasses treatment, storage, transportation, and/or disposal of nonhazardous, conventional radioactive, infectious and hazardous solid wastes. The terms *solid* and *hazardous* are used as defined in the RCRA. A *solid waste* is a solid, liquid, or gas that is discarded, abandoned, or, in some cases, reused by recycling or burning for energy recovery. *Hazardous wastes* are a subset of solid wastes that RCRA designates and regulates as hazardous. Mixed wastes contain both hazardous and radioactive components.

8.1.2 Regulations and Guidance

This section describes the regulations that govern the management of solid waste and the DOE orders that implement these regulations.

8.1.2.1 Federal and state compliance

RCRA, enacted in 1976, is the prominent regulation governing solid waste management activities. RCRA regulates the generation, transportation, treatment, and disposal of hazardous wastes and regulates facilities that conduct these activities. Source materials, special nuclear materials, and by-product materials are excluded from RCRA. However, radioactive material mixed with hazardous wastes is regulated by both RCRA and the Atomic Energy Act (AEA). Hazardous wastes are defined in RCRA by specific source lists, nonspecific source lists, characteristic hazards, and discarded commercial chemical product lists. Other portions of RCRA pertinent to the Oak Ridge installations include standards for transporters of hazardous waste; standards for owners and operators of hazardous waste treatment, storage, and disposal facilities; permit requirements for treatment, storage, or disposal of hazardous wastes; inspections; federal enforcement; hazardous waste site inventory; and corrective action requirements.

To obtain compliance with RCRA, the Oak Ridge installations must submit permit applications to environmental regulators for each hazardous waste treatment, storage, or disposal facility. Part A permit applications (interim status) were submitted in 1984, and Part B permit applications (operating) are being revised for all similar RCRA operating units. Treatment, storage, or disposal units obtain interim status through the Part A permit application process and are required to meet the design and management standards for interim facilities set forth in RCRA. Facilities receive full permit status through the Part B Permit application and approval. Facilities with interim status have the option of filing for closure and cease operations instead of filing for a Part B permit application, which requires more stringent standards.

Additional RCRA Part A and Part B applications are submitted as new storage and/or treatment units are needed for the management of hazardous wastes. The TSCA governs the labeling, handling, and disposal of wastes or articles containing PCBs. The Clean Water Act requires use of BMPs and compliance with the NPDES permit, and the Clean Air Act requires compliance with air emissions standards.

8.1.2.2 DOE orders

Management of radioactive wastes, waste by-products, and radioactively contaminated facilities is governed by DOE Order 5820.2A, which applies to all DOE elements, contractors, and subcontractors that manage radioactive waste as defined in the AEA of 1954 (as amended). Guidelines are provided for characterization, storage, and disposal of high-level radioactive wastes, LLW, TRU wastes, wastes contaminated with naturally occurring radionuclides, and decommissioning wastes.

Hazardous and mixed waste management at the Oak Ridge facilities is conducted under DOE Orders 5400.1 and 5400.3, as well as the AEA, the RCRA of 1976, and its Tennessee equivalent, the Tennessee Hazardous Waste Management Regulations. DOE Order 5400.1 requires that hazardous waste generated by DOE-funded activities be managed in an environmentally acceptable manner. DOE Order 5400.3 provides the requirements for hazardous waste management programs implemented at DOE-funded installations. The AEA of 1954, as amended, dictates provisions for establishing regulations that govern processing and use of source, by-product, and special nuclear materials.

8.1.3 Compliance Activities

8.1.3.1 Y-12 Plant

To obtain compliance with RCRA, the Y-12 Plant submits applications to environmental regulators for each hazardous waste treatment, storage, or disposal facility. Twenty Part B permit applications and six postclosure permit applications have been filed for the Y-12 Plant facilities.

Information required for a Part B permit application includes general facility description, waste characterization, and analysis plans; information on processes generating the waste; procedures to prevent hazards; contingency plans; and closure and postclosure plans. After negotiation and acceptance of Part B, the Y-12 Plant facilities will be fully permitted under RCRA and subject to stringent guidelines specified in 40 CFR Part 264. The facilities are inspected regularly by EPA, TDC, DOE, and/or internal auditors to ensure RCRA compliance.

In CY 1990, four Y-12 Plant RCRA facilities have been closed in accordance with TDC-approved closure plans. These were the New Hope Pond, S-3 Ponds, Oil Retention Ponds, and C-West. Closure activities are under way on an additional two disposal areas as a part of the Closure and Post Closure Activities project. The two facilities are Kerr Hollow Quarry and the Walk-in Pits.

Nonhazardous, nonradioactive solid waste disposal sites are permitted in accordance with the Tennessee Solid Waste Disposal Act. To meet the requirements of the act, documentation that included construction drawings and design and operating plans was submitted to the regulators for approval; subsequently, permits were issued for the Y-12 Centralized Sanitary Landfill II, the Y-12 Spoil Area I, and Industrial Waste Landfill IV. All regulated facilities are inspected periodically by the regulators. Applicable discharges to surface waters are through monitored discharge points that comply with the plant's NPDES permit.

An Environmental Assessment (EA) for the Y-12 Steam Plant Ash Disposal Project is currently under preparation. The EA evaluates alternatives for disposal of dewatered bottom ash as well as nonradioactive, nonhazardous, industrial, and sanitary wastes generated at Y-12 Plant, the K-25 Site, and ORNL.

8.1.3.2 Oak Ridge National Laboratory

Waste treatment and disposal activities are regulated by TDC and EPA through operating permits. ORNL operates (1) several hazardous waste treatment, storage, and disposal facilities under an interim-status RCRA permit and (2) the Hazardous Waste Storage Building (Building 7652), which operates according to a full RCRA Part B permit granted in October 1986. Chemical and mixed wastes are regulated through these permits. Y-12's Sanitary Landfill II is used for the disposal of nonhazardous materials such as fly ash and construction debris. It operates under a permit from the TDC Division of Solid Waste Management. Process wastes are treated on-site in the process wastewater treatment facility, which discharges to surface water through a monitored discharge point that must comply with ORNL's NPDES permit. The NPDES permit is regulated by TDC and EPA. Radioactive waste disposal must comply with DOE orders: RCRA requires that the potential for environmental release of radioactive materials be investigated and corrective actions taken. Thus, all waste-handling activities are regulated and inspected for compliance by state and federal agencies as well as through internal audits.

TRU wastes generated at ORNL are being placed in retrievable storage. Current activities center around certification of contact-handled (CH) waste, planning/designing of a repackaging and certification facility for remote-handled (RH) wastes, and planning for shipment of wastes to the Waste Isolation Pilot Plant (WIPP) in New Mexico.

8.1.3.3 K-25 Site

During 1988, the K-25 Site elected to file for closure and ceased RCRA operation of four facilities. The plant also filed a permit-by-rule request for two facilities. In September 1989, the K-25 Site received 11 permits from TDC. Ten of these permits are for RCRA storage units, and one is for closure of 1407-B Pond. Because of appeals, the storage areas have reverted to interim status.

The TSCA regulations govern the labeling, handling, and disposal of wastes that contain PCBs. PCB wastes that contain radioactive contamination cannot be disposed of by commercial facilities. These wastes will be disposed of at the K-1435 incinerator. Other environmental regulations also impact solid waste management activities. CWA requires the use of BMPs and compliance with NPDES. CAA requires permitting of air emissions.

8.1.4 Program Strategy

Overall corporate strategies for the management of radioactive, hazardous, and mixed wastes have been developed for Energy Systems. These strategies are based on the following guiding principles.

- Reduce the quantity of solid waste generated.
- Minimize the amount of wastes stored on-site.
- Characterize and certify the wastes prior to storage, processing, treatment, or disposal.
- Use on-site storage where this can be shown to be safe and cost-effective until a final disposal option is selected.
- Determine the effectiveness of promising technologies in the solution of local problems.
- Maximize the involvement of private-sector contractors in conducting technology demonstrations and in implementing successful technologies.

More specifically, the radioactive waste management program is based on the following technical assumptions.

- Waste will be segregated by half-life and hazard consistent with the overall waste management strategy.
- The level of containment required and, therefore, the type of treatment and/or disposal required will be a function of the half-life and hazard, including potential mobility, of the waste.
- Engineered features cannot be relied on to contain long-half-life wastes without surveillance, remediation, and long-term maintenance.
- Management of long-half-life wastes must rely on concentration limits, natural features, and institutional control/perpetual care to provide for the maintenance of engineered features and to protect against intrusion.

TRU wastes will be managed in accordance with the TRU Waste Program strategy, which relies on certification and packaging at the site and shipment to WIPP for ultimate disposal.

LLW will be managed in accordance with DOE Order 5820.2A, "Radioactive Waste Management." The general strategy for management of LLW is being defined by the Reservation Waste Management Division (RWMD).

The primary goal of the strategy for LLW is the management and ultimate disposal of solid radioactive waste in a manner that protects the environment and public health and safety at all times. For the disposal of LLW, the strategy establishes dose-based performance objectives that protect the public, minimize releases, and reduce the probability for the need to do remedial actions after the disposal facilities are closed. The key components of the strategy are

- the dose-based performance objectives for disposal of LLW,
- a waste classification system for managing different wastes to meet the dose-based performance objectives,

- the planned use of engineered features and barriers,
- the waste acceptance criteria (WAC) for each disposal site for achieving the dose-based performance objectives for that specific site with appropriate engineered features,
- a waste certification program for ensuring that the wastes for disposal meet the applicable WAC,
- the use of pathways analysis modeling to establish radionuclide concentration limits for the WACs and to predict whether a selected site and technologies will achieve the performance objectives, and
- phased implementation.

Using this general strategy, Energy Systems has proposed five classes of LLW.

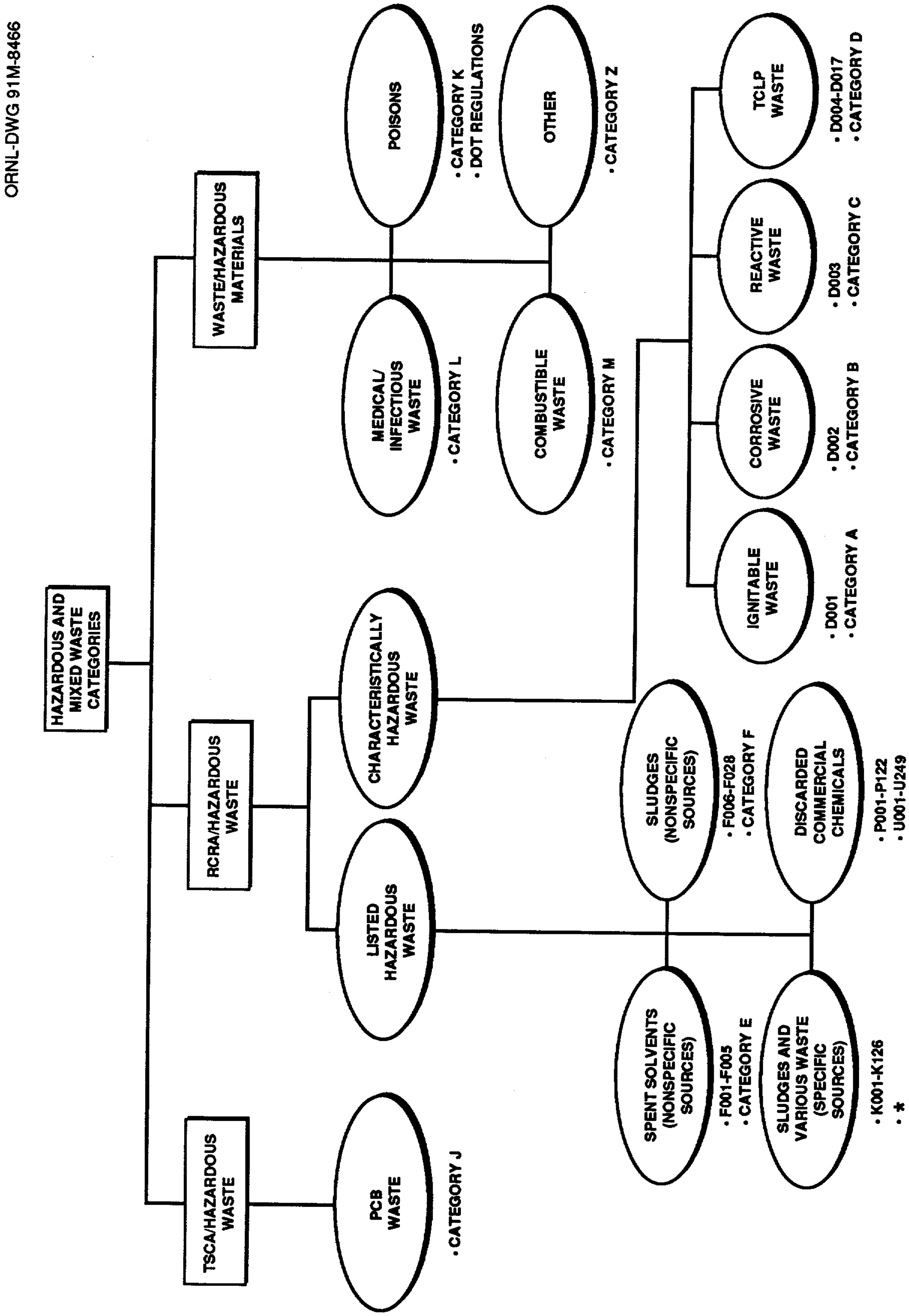
1. **Below regulatory concern (BRC) waste.** LLW that is suitable for disposal in a sanitary/industrial landfill and will not expose any member of the public to an effective dose equivalent of more than 4 mrem/year at the time of disposal.
2. **Class L-I waste.** LLW that is suitable for disposal using sanitary/industrial landfill disposal technology and will not expose any member of the public to an effective dose equivalent of more than 10 mrem/year at the time of disposal.
3. **Class L-II waste.** LLW primarily containing fission product radionuclides with half-lives of 30 years or less that is suitable for disposal in engineered facilities designed to isolate the waste from the environment and public for a period of time sufficient to allow for the decay of radionuclides to such a level that any member of the public will not be exposed to an effective dose equivalent of more than 10 mrem/year.
4. **Class L-III waste.** LLW consisting of radionuclides that have long half-lives and will be disposed of in facilities having permanent intruder protection.
5. **Class L-IV waste.** LLW not suitable for disposal on the Oak Ridge Reservation (ORR) and that would require either treatment to reduce the level of contamination to a level consistent with any of the other waste classifications or shipment to an off-site LLW disposal facility.

The general strategy to be followed for the management of hazardous and mixed wastes will ensure the continuation of present management operations while simultaneously initiating a technology development and demonstration program for current and future problem waste streams. Fundamental to this general strategy are the following components: (1) waste stream identification and evaluation; (2) waste minimization/reduction; (3) on-site storage/treatment, RCRA hazardous wastes; (4) on-site storage/treatment, mixed wastes; (5) technology demonstrations; (6) delisting, detoxification, and mobility reduction; and (7) waste disposal activities.

The Hazardous Waste Development, Demonstration, and Disposal (HAZWDDD) Program developed a general classification system based on the RCRA and TSCA regulations (Fig. 8.1). Treatment options are evaluated for each category of problem waste using process flowcharts. Where technology currently exists, preferred treatment options are identified. When proven technologies do not exist, studies, evaluations, or technology demonstrations will be conducted. In general, the preferred treatment option for categories A (ignitables), E (spent solvent), J (PCB wastes), L (medical/infectious waste), and M (combustibles) is incineration. For category D (TCLP-toxic wastes), the preferred option is stabilization (surface decontamination, followed by stabilization, for surface-contaminated wastes), and the preferred option for category F (sludges) is thermal treatment and/or stabilization. The preferred treatment option(s) for categories B (corrosives), C (reactives), K (poisons), U (unknown), and Z (hazardous, but not EPA-listed) depend on complete waste characterizations.

Mixed wastes are currently being placed in interim storage as new technologies for treatment and disposal are identified and evaluated. Solid LLW, with the exception of some special case wastes, is currently placed in interim storage at the K-25 Site awaiting development of treatment/disposal facilities consistent with the LLW strategy being developed and refined by the RWMD.

PCB waste is managed to ensure compliance with PCB regulations and to minimize the risk of CERCLA or civil liabilities. It is the policy of Energy Systems to comply with the letter and spirit of the PCB regulations. In certain instances where the intent of the rule can clearly be met but where the letter of the rule may create substantial hardships, the EPA



* Not categorized for HAZWDDD because none of these listed wastes is produced at the MMES sites.

Fig. 8.1. Hazardous and mixed waste categories developed for the HAZWDDD Plan.

regional administrator may be petitioned for a waiver. Such petitions will be made through DOE.

At the present time, an Environmental Impact Statement (EIS) is being prepared that addresses the general waste management strategies and specific LLW disposal facilities on the ORR. DOE Order (5820.2A) for radioactive and mixed waste management was issued in September 1988. The order has had and will continue to have a significant impact on future radioactive and mixed waste management operations. The K-25 Site's implementation plan for the order was submitted to DOE in April 1989, and the waste management plan for the order was submitted in January 1990. These plans identify the actions, schedules, and costs necessary to eliminate noncompliances with the order.

8.1.4.1 Y-12 Plant

Current strategy for solid waste management consists of waste reduction, storage, treatment, delisting, and disposal. Each concept is an integral portion of the overall waste management strategy. Mixed waste storage is necessary to ensure compliance with environmental regulations while treatment and disposal techniques are identified and implemented and during the delisting process. Also, the proper identification, characterization, and classification of waste materials are essential to ensure that waste management activities are performed safely, efficiently, and in compliance with regulations and policies.

Solid waste as categorized at the Y-12 Plant is listed in Table 8.1. RCRA hazardous wastes are candidates for commercial recovery or disposal programs; mixed wastes, which contain both RCRA hazardous and radioactive components, are not candidates for commercial recycle or disposal.

Ideally, after strategy implementation, most solid wastes that are generated will be conventional sanitary/industrial wastes. When this is not possible, prudent management will minimize the amount of other wastes present. Six major waste-minimization options are available at the Y-12 Plant: segregation, material substitution, process innovation, mechanical volume reduction, recycle and/or reuse, and treatment. These options are not mutually exclusive and may be combined to suit the specific needs.

To properly characterize wastes and determine the appropriate storage or disposal modes, a comprehensive system of administrative controls, inspections, sampling, analysis, and monitoring is used. Sampling and analytical programs are in place for hazardous, nonhazardous, and mixed waste streams. In addition to characterization by sampling, low-level waste monitoring for bulk wastes is accomplished using external radiation monitors.

Table 8.1. Y-12 Plant waste generation summary for 1990

Waste	Quantity (kg)
Sanitary/industrial	10,756,145[a]
Asbestos/BeO	
Uncontaminated	217,270
Contaminated	84,638
Hazardous[b]	2,136,440
Mixed	3,880,486
PCB	81,888
PCB/uranium	10,661
Low-level contaminated waste[c]	1,960,042
Scrap metal	
Uncontaminated	1,209,297
Contaminated	587,865
Classified	44,387
Nonhazardous liquids[d]	554,701

[a]This includes construction/demolition spoil and fly ash.

[b]This does not include Steam Plant regeneration waters.

[c]This category consists of industrial wastes.

[d]This category consists of waste oils, mop waters, and other nonhazardous liquids. Does not include the Steam Plant Wastewater Facility wastewater.

Also, to improve characterization of potentially low-level radioactive waste streams, the Y-12 Plant continues with procurement, installation, and testing of more effective waste monitoring equipment, including a crated waste assay monitor and waste curie monitors.

A variety of disposal options are available to manage the wastes generated at the Y-12 Plant. On-site treatment for disposal/storage includes oxidation of uranium machine turnings; batch physiochemical treatment of liquid wastes; biodenitrification of aqueous nitrate waste; and baling of solid, low-level radioactive wastes. On-site disposal capability includes shallow land burial for solid, noncontaminated, industrial waste and discharge through NPDES discharge points after treatment for aqueous wastes. Off-site disposal options include disposal of hazardous waste by commercial vendors. Long-term storage options include storage in warehouses, tanks, and vaults at the Y-12 Plant, as well as storage of Y-12 Plant wastes in buildings at the K-25 Site. More detailed information on each of these options is presented in Sect. 8.3.2.

Several LLWDDD-related, Y-12 Plant-sponsored technology demonstrations have been completed, including supercompaction, shape alteration, and the laboratory characterization task of the Uranium Lysimeter Demonstration.

In addition, demonstrations that were well into the planning or implementation phases in 1990 included a BRC demonstration and the field task of the Uranium Lysimeter Demonstration. Activities related to these projects are expected to cease in 1991, however, because of a lack of funding.

Activities planned under the now defunct HAZWDD program have been continued and are currently planned through FY 1992. Technology demonstrations are being funded so that commercially available treatment processes can be tested on Y-12 wastes. Priority is being given to work on waste streams for which no disposal outlet has been identified. The program will include full-scale commercial treatment efforts pending the outcome of treatability studies. Soils contaminated with mercury and/or chlorinated organic compounds are wastes included in this program.

Demonstrations for removal of hazardous or radioactive constituents in soils have been completed. Results of the demonstrations will be evaluated for further use in applying this technology to larger-scale treatment projects. A single demonstration has been completed to initiate an evaluation of incineration technology for LLW. Final results of the demonstration indicated that incineration of combustible low-level radioactive waste is feasible. A full-scale low-level waste volume reduction project was initiated in 1990 that used the incineration technology.

A project is currently under way to evaluate the potential for delisting a sludge generated by wastewater treatment facilities at the Y-12 Plant. The preliminary sampling and analytical results were favorable, but the EPA suggested that a more rigorous sampling method be used. Work to devise and implement such a method is in progress.

Two demonstrations have been scoped and were initiated in FY 1990. The demonstrations will evaluate the removal of hazardous and radioactive constituents in sludges from wastewater treatment facilities and from oils and solvents used at the Y-12 Plant.

8.1.4.2 Oak Ridge National Laboratory

Wastes are identified initially through their generating processes and can be grouped into the broad categories shown in Fig. 8.2. Although knowledge of the generating process helps in identifying the waste constituents, this depth of characterization is often not sufficient to allow for proper waste handling. Hence, more detailed waste characterization is often conducted before treatment or disposal. Wastes are analyzed using standard EPA and DOE-approved analytical methods. In addition, all wastes are checked for radioactive contamination.

It is ORNL policy to minimize all categories of wastes by reducing waste volume and/or toxicity, thereby reducing the need for waste treatment and disposal and their potential environmental consequences. This reduction can be achieved through process modification, segregation, minimization, or recycling.

One example of process modification that effectively reduces the amount of hazardous waste generated is a procedural change in the Analytical Chemistry Division. Many chemical analyses are now done on small-volume samples using small volumes of solvents for extractions, which reduces the total volume of waste solvent generated.

Waste segregation is used to minimize the generation of solid low-level radioactively contaminated wastes. By providing collection barrels for both radioactive and nonradioactive wastes, the volume of wastes that requires handling as radioactive waste has been reduced. Before these procedures were implemented, radioactive and nonradioactive wastes were discarded in the same barrel. This contaminated the nonradioactive portion and required special disposal of an inflated amount of waste.

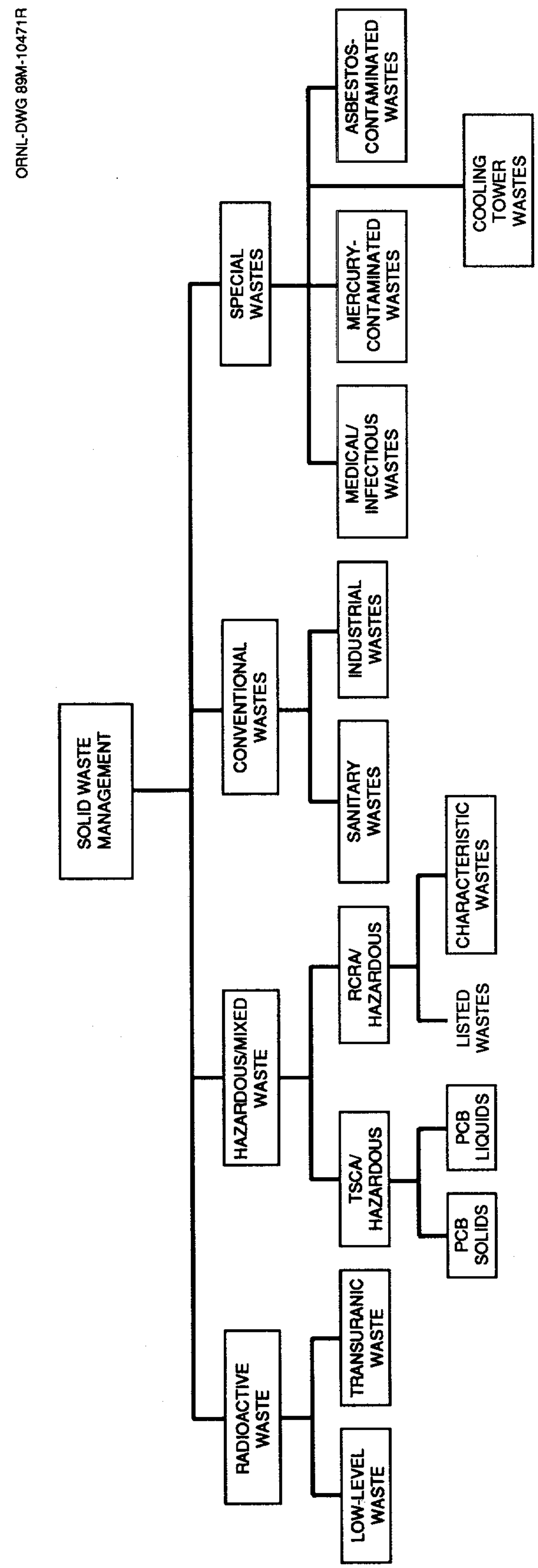


Fig. 8.2. Categories of solid waste sources and flow of mixed wastes.

ORNL's procurement policy is an example of minimization. In the past, researchers took advantage of the reduced cost of bulk purchasing; however, the excess purchased was often discarded as waste. By purchasing only the quantity of a chemical needed, less waste is produced.

Examples of recycling include making unneeded chemicals available to others rather than discarding them as wastes; using acceptable waste corrosives in a neutralization facility in place of new acids and bases; and recovering silver from silver-bearing photographic wastes.

Despite these efforts, some wastes will be produced. Minimizing the impact on public health and the environment is the goal of the waste management program. To achieve this goal, some wastes, such as sanitary wastes, are treated on-site while others, such as low-level solid wastes, are disposed of on-site in SWSAs. Off-site treatment is the best management option for many hazardous and PCB-contaminated wastes. Most hazardous laboratory and PCB-contaminated wastes are incinerated in permitted facilities. Although more expensive than land disposal, destruction by incineration is preferable for minimizing long-term liability. Transuranic waste and mixed waste are in long-term storage on-site until appropriate storage, treatment, or disposal options become available. Solid waste management strategies depend on the type of waste and are chosen because they are the most prudent approaches currently available.

8.1.4.3 K-25 Site

The strategy for the management of solid waste consists of treatment, storage, disposal, waste reduction, and/or delistings of all waste streams generated at the K-25 Site. Waste streams are evaluated using process knowledge and analytical waste characterization. Samples are collected and analyzed using EPA- and DOE-approved methods. Radioactive analyses are performed on an as-needed basis, with surveys and scans performed on suitable materials and configurations.

The K-25 Site policy mandates minimization of waste generated while achieving compliance with applicable environmental regulations. Five waste reduction options are used at the K-25 Site: segregation, material substitution, process innovation, mechanical volume reduction, and recycle/reuse. These options may be used alone or in combination to address specific goals.

The K-25 Site management supports the waste reduction program. Excellent examples of the program at work include the procedure for procuring hazardous materials, the use of waste assay monitors to reduce the volume of LLW requiring management, i.e., storage, and the conversion to gas-fired boilers to reduce opacity excursions, and in effect, reduce/eliminate fly ash production. In the past, hazardous materials were purchased in larger quantities to take advantage of the less expensive bulk rates. However, a hidden cost of this procurement method was the expense of disposal of the excess material. Current procedure for the purchase of hazardous materials requires the approval of the Plant Hazardous Materials Coordinator. This minimizes the purchase of excess hazardous materials and, thus, the need to dispose of excess quantities.

Several treatment, storage, and disposal options are available to manage the wastes generated at the K-25 Site. On-site storage facilities are available for LLW, RCRA wastes, and mixed wastes. On-site treatment capabilities include the K-1435 TSCA Incinerator, the Central Neutralization Facility, and other facilities for neutralization, precipitation, and stabilization. The K-25 Site utilizes the Y-12 Plant Centralized Sanitary Landfill II for disposal of sanitary/industrial solid wastes. On-site disposal includes discharge of aqueous wastes through NPDES discharge points after treatment. Off-site disposal options include disposal of RCRA hazardous and nonregulated wastes by commercial vendors. Waste assay monitors have also been purchased and are being used to screen solid, potentially radioactive waste to determine the potential to manage it as sanitary/industrial waste. This, in effect, allows valuable storage space to be dedicated to those wastes actually requiring long-term management. All boilers at the K-25 Site will be completely converted to gas-fired by 1992. This will reduce/eliminate opacity excursions, with a secondary derived benefit being the curtailment of fly ash production.

8.2 WASTE GENERATION

8.2.1 Types of Wastes Generated

Following is a brief summary of the types of wastes generated at ORR.

Sanitary/industrial wastes. Industrial trash consisting of paper, wood, metal, glass, plastic, etc., coupled with large volumes of construction/demolition debris and small volumes of sanitary/food wastes from cafeteria operations. Also included in this category is fly ash from steam plant operations and other special wastes. This is regulated by the Tennessee Solid Waste Management Act (TSWMA).

RCRA hazardous wastes. Solid wastes (including liquids) that are defined as hazardous by RCRA regulations as a consequence of being a listed waste or having a hazardous characteristic. Hazardous wastes include chemicals that are characteristically hazardous or listed by RCRA in 40 CFR 261.33. These wastes are managed in accordance with DOE Orders 5400.1 and 5400.3 and state and federal regulations.

Mixed wastes. RCRA hazardous wastes that are also contaminated with low-levels of uranium or other radioactive material.

PCB wastes. PCB oils or materials that have been contaminated with PCB. These are regulated by TSCA. These waste streams may or may not be radioactively contaminated. Radioactively contaminated waste cannot be disposed of through commercial disposal facilities. Any TSCA waste that is radioactively contaminated is placed in storage for future disposal at the K-1435 incinerator.

Low-level radioactive wastes. Solid wastes (including liquids) that are composed of isotopically depleted uranium metal or oxide or that contain low levels of uranium or other radioactive contamination. LLW are managed according to DOE Order 5820.2A and AEA.

Asbestos/beryllium oxide wastes. Solid wastes that have been contaminated with either asbestos or beryllium oxide, which classifies the waste as a special waste. The waste may also be contaminated with low levels of uranium.

Scrap metal. Derived primarily from demolition activities. The scrap may be either nonuranium contaminated or contaminated with low levels of uranium.

Classified wastes. Classified wastes include liquid and solid streams containing materials that, for security reasons, are restricted by DOE criteria. Classified wastes are managed in accordance with DOE Order 5632.1. These wastes could be contaminated with low levels of radioactivity.

Medical wastes. Medical and infectious wastes consist of contaminated bandages, sharps, and cultures media. These wastes are placed in biological disposal containers and autoclaved to destroy any biologically active organisms. The waste is then landfilled at the Y-12 Centralized Sanitary Landfill II.

Nonhazardous wastes. All other types of wastes (including liquids) that are nonhazardous or nonradioactive, or both.

Material access area (MAA) wastes. Wastes that are removed from MAAs include combustible and compactible materials (paper, wood, wipes, etc.) and noncombustible and noncompactible materials (dirt, concrete, block, rubble). The waste contains low concentrations of enriched uranium and has been monitored to verify that the uranium concentrations are below levels of concern for accountability, recoverability, and security control.

8.2.2 Waste-Generating Activities

8.2.2.1 Y-12 Plant

Major waste-generating activities at the Y-12 Plant include construction/demolition activities that produce large volumes of contaminated and noncontaminated wastes, including lumber, concrete, metal objects, soil, and roofing materials. Wastes contaminated with hazardous materials are also generated by construction/demolition activities.

Machining operations use stock materials, including steel, stainless steel, aluminum, depleted uranium, and other metals to produce significant quantities of machine turnings and fines as a waste product.

The Y-12 Steam Plant produces steam by burning coal, which produces fly ash and bottom ash as a waste product.

Industrial trash, both noncontaminated and uranium contaminated, is generated by daily operations throughout the plant. These operations include janitorial services, floor sweeping in production areas, and production activities.

In addition, plating waste solutions are generated by metal-plating operations, and reactive wastes and waste laboratory chemicals are generated from various laboratory activities.

Table 8.2. Y-12 Plant radioactive waste data for 1990

Radionuclide	Activity (Ci)
^{235}U	0.11
^{238}U	5.9
^{232}Th	0
^{99}Tc	0
^{237}Np	0

Liquid process wastes are generated from multiple processes throughout the plant. Sludges are generated as a result of treating process wastes at multiple sites, and waste oils and solvents are generated from machining and cleaning operations.

Contaminated soil, soil solutions, and soil materials are generated from closure activities associated with RCRA closures.

These are only a few of the industrial-type activities at the Y-12 Plant that are generating waste streams at the site. A summary of waste generation for 1990 is given in Tables 8.1 and 8.2.

8.2.2.2 Oak Ridge National Laboratory

Because ORNL is a research facility, it has many diverse waste-generating activities, each of which may produce only a small quantity of waste. Isotope production, utilities, and support functions such as photography are additional sources of waste. A summary of waste generation for 1990 is given in Table 8.3.

Hazardous wastes are generated in laboratory research, electroplating operations, painting operations, descaling, demineralizer regeneration, and photographic processes.

Mixed wastes are generated by research projects and some facility operations. Facility renovation and demolition activities produce asbestos. Although the electrical system has been largely converted to a non-PCB system, PCB-contaminated wastes, including fluorescent light ballasts and capacitors, are still occasionally discarded. Additionally, Energy Systems policy requires that waste materials containing greater than 2 ppm PCBs be managed according to TSCA requirements.

Nonhazardous wastes result from ORNL maintenance and utilities. For example, the steam plant produces nonhazardous sludge. Scrap metals are discarded from maintenance and renovation activities and are recycled when appropriate. Construction and demolition projects also produce nonhazardous industrial wastes. All nonradioactive medical wastes are autoclaved to render them noninfectious and are sent to the Y-12 Plant Sanitary Landfill. Isotope production and research activities generate a variety of low-level radioactive and transuranic wastes, as shown in Table 8.4. Remedial action projects also produce wastes requiring proper management.

Table 8.3. 1990 ORNL waste generation summary

Waste	Volume (m^3)	Weight (kg)
Hazardous		71,000
Sanitary Industrial	12,200	
Mixed		4,900
PCB[a]		
Radiological		22
Nonradiological		12,000
Transuranic		
Contact handled	5.5	
Remote handled	0	
Low-level wastewater, gal	4.2×10^5	
Asbestos		
Radiological		6,600
Nonradiological		15,237
Scrap metal		
Radiological		24,000
Nonradiological		416,340
Miscellaneous		
Nonhazardous		1,535
Miscellaneous		
Radiological	0	

[a]Martin Marietta Energy Systems policy defines any material with PCB contamination >2.0 ppm as PCB waste.

8.2.2.3 K-25 Site

Enrichment, maintenance, decontamination, and research and development (R&D) activities have

Table 8.4. 1990 ORNL radioactive waste data

Radionuclide	Curies	Radionuclide	Curies
^{241}Am	1.3	^{63}Ni	0.28
^{243}Am	0.0085	^{237}Np	0.074
^{39}Ar	0.0013	^{191}Os	0.068
^{10}Be	0.0032	^{32}P	0.000002
^{14}C	0.075	^{210}Pb	0.017
^{249}Cf	0.00021	^{103}Pd	2.39
^{252}Cf	0.063	^{147}Pm	0.51
^{243}Cm	0.000012	^{195}Pt	0.0024
^{244}Cm	1.2	^{238}Pu	0.0081
^{57}Co	0.011	^{239}Pu	4.80
^{58}Co	38	^{241}Pu	0.055
^{60}Co	2,200	^{226}Ra	0.0043
^{51}Cr	0.015	^{229}Ra	0.0032
^{134}Cs	86	^{106}Ru	0.00017
^{137}Cs	380,000	^{35}S	0.00094
^{64}Cu	20	^{119m}Sn	0.035
^{152}Eu	490	^{85}Sr	0.0030
^{154}Eu	310	^{90}Sr	1,000
^{155}Eu	10	^{179}Ta	0.099
^{55}Fe	0.052	^{182}Ta	12,000
^{59}Fe	1,300	^{99}Tc	0.41
^{153}Gd	1.7	^{228}Th	0.0013
^{68}Ge	0.061	^{229}Th	0.0077
^{3}H	620	^{232}Th	0.0011
^{125}I	0.072	^{204}Tl	0.050
^{131}I	1.0	^{232}U	0.011
^{192}Ir	28	^{233}U	4.2
^{40}K	0.0017	^{234}U	0.00060
^{43}K	0.00083	^{235}U	0.0028
^{85}Kr	0.024	^{236}U	0.000066
MFP[a]	0.00033	^{238}U	0.0086
^{54}Mn	33	^{188}W	0.0031
^{22}Na	0.020	^{90}Y	0.044
		^{95}Zr	0.000055

[a]Mixed fission products.

generated a wide variety of waste at the K-25 Site. Until August 1985, the primary function of the site was the enrichment of uranium in the ^{235}U isotope. Uranium is the predominant radionuclide found in the K-25 Site waste streams.

Small quantities of ^{99}Tc, ^{237}Np, and ^{239}Pu may have also been present in some of the waste streams because these radionuclides were present in UF_6 reactor return feed material that was shipped to the K-25 Site for enrichment.

Solid low-level wastes are generated by discarding radioactively contaminated construction debris, wood, paper, asbestos, trapping media, and process equipment and by removing radionuclides from liquid and airborne discharges.

Currently, low-level solid wastes are being stored at the K-25 Site for future disposal.

All contaminated scrap metal is stored aboveground at the K-770 scrap metal facility until further disposal methods are evaluated.

Sludges contaminated with low-level radioactivity are generated by settling and scrubbing operations and were stored in K-1407-B and K-1407-C ponds in the past. Sludges have been removed from these ponds and a portion have been fixed in concrete at K-1419 and stored aboveground at K-1417. These materials are considered mixed waste, and a delisting petition has been submitted to the EPA. Recent findings suggest the need to reevaluate the management scheme for the raw and stabilized sludges.

The primary generator of radioactively contaminated liquid waste is the uranium decontamination and recovery facility. This waste stream is currently being treated at the K-1407-H CNF.

Other waste streams generated at the K-25 Site include RCRA hazardous chemicals and materials, PCB articles and items, industrial/sanitary wastes, waste oils and solvents, and remedial action type wastes.

All waste streams generated at the K-25 Site are managed according to applicable state and federal regulations and DOE orders (see Table 8.5). Several waste management facilities are already in place. Changing laws and regulations have made it necessary to upgrade several facilities and to design and construct new facilities that reflect the most recent environmental technology.

Table 8.5. K-25 Plant waste generation summary for 1990

Waste	Quantity
Sanitary/industrial (m^3)	6,796
Concentruction/demolition spoil (m^3)	173
Fly ash (m^3)	0
Asbestos/BeO	
Uncontaminated (m^3)	1,332
Contaminated (m^3)	75
Hazardous[a] (kg)	8,506,883
Mixed[b] (kg)	315,940
PCB (kg)	21,776
PCB/uranium (kg)	12,480
Low-level contaminated waste[b] (m^3)	491
Scrap Metal	
Uncontaminaged (kg)	42,927
Contaminated (kg)	226,362
Classified (kg)	1,000

[a]Includes 8,420,000 kg of hydrogen softener blowdown from the steam plant; may include some PCB-tainted waste.
[b]May include some PCB-tainted waste.

8.3 WASTE MANAGEMENT ACTIVITIES

8.3.1 Waste Management System

Special forms specifically designed for each plant are used to document and track wastes. A list of these forms follows.

Y-12	Form UCN-2109	Request for Disposal of Hazardous Chemicals, Gases and Radioactive Materials
ORNL	Form UCN-12463	Request for Disposal/ Storage of Waste Materials and Equipment
K-25	Form UCN-12463	Request for Disposal/ Storage of Waste Materials and Equipment

Wastes must be adequately characterized through chemical analyses or process knowledge to determine appropriate treatment, storage, and disposal options. This is documented on the form. Additional forms may be used at the sites to document special waste streams such as classified wastes, asbestos/beryllium oxide, and spoil materials.

A Health Physics staff member surveys the waste for radioactivity. Waste generation is reduced by recycling and segregation whenever feasible. The waste transportation group at each site checks the form for accuracy, assigns a hazard class and the EPA hazardous waste number, and transports the waste to a hazardous waste management facility. The waste transportation group maintains an inventory logbook for each storage facility.

Information concerning waste generation, storage, transportation, and disposal activities is maintained on computerized and/or manual databases. Data from the forms and other documentation are compiled to ensure compliance with all applicable state and federal regulations and to promote efficient waste management operations.

Computer-based databases facilitate waste tracking and the generation of waste management reports. Hard copies of forms are kept on permanent file.

8.3.2 Waste Management Facilities

8.3.2.1 Y-12 Plant

Nonhazardous

The Y-12 Centralized Sanitary Landfill II is a TDC-permitted facility that became operational in 1983. It serves the K-25 Site, ORNL, the Y-12 Plant, and other DOE prime contractors and their subcontractors in the Oak Ridge area. Combustibles, decomposable materials, and other industrial wastes are permitted, as are certain special wastes such as asbestos, beryllium oxide, aerosol cans, fly ash, and others. These materials are disposed of in large trenches, and a clay cover is applied daily. This facility is operated as described in Report Y-EN 618, Design and Operating Procedures for the Y-12 Centralized Sanitary Landfill II.

The Y-12 Spoil Area I is a shallow land burial facility for the disposal of noncontaminated rubble and construction spoil, including asphalt, brick, block, brush, concrete, dirt, rock, tile, and other similar materials. This TDC-permitted facility is operated in accordance with Report Y/IA-167, Design and Operating Procedures for the Y-12 Spoil Area I.

The Chestnut Ridge Borrow Area Waste Pile serves as a storage/disposal area for soils with low concentrations of mercury and is operated in accordance with Report Y/TS-62, Design and Operating Procedures for the Chestnut Ridge Borrow Area Waste Pile. The facility is covered with a synthetic liner and has run-on and runoff protection.

The current plans are to seek closure of this site under TDC Solid Waste Management rules for special wastes.

Lake Reality is a lined containment basin with a surface area of approximately 2 acres. The pond serves to enhance the water quality of EFPC downstream of the Y-12 Plant.

Industrial Landfill IV is a TDC-permitted landfill for disposal of nonhazardous, nonradioactive, classified wastes from the Y-12 Plant.

The Garage Oil Storage Tank is a 37,854-L (10,000-gal) UST that contains used, clean oil for sale to the public.

The salvage yard is used for the staging and public sale of nonradioactive, nonhazardous scrap metal.

Oil Storage OD6 is a 113,562-L (30,000-gal) tank that was used to collect clean oils before sale to the public. This facility is no longer operational.

Rogers Quarry is used as a settling pond for bottom ash sluiced from the steam plant. The use of Rogers Quarry for ash settling will be discontinued when the Steam Plant Ash Disposal (SPAD) Line Item is completed in FY 1992. At that time, bottom ash will be collected in a dedicated ash handling system and disposed of in the Y-12 Sanitary Landfill.

The UNC Landfill is a surface storage area for nitrate-contaminated sludges and soils. Plans for closure of this facility have been approved. The closure activities are described in the Report Y/IA-200, *Closure Plan for the United Nuclear Corporation Waste Disposal Site.*

The Sludge Handling Facility (T-118) was designed and constructed to provide water filtration and sludge dewatering in support of a storm sewer cleaning and relining project. Filtered water was reused by the sewer cleaning contractor, and the dewatered sludge was stored in specially constructed containers for future disposal. The facility began receiving material during the winter of 1986 and was removed from operation at the end of the project during the fall of 1987.

The Plating Rinsewater Treatment Facility (PRTF) (T-036) provides neutralization, electrochemical reduction, chemical precipitation, carbon adsorption, and filtration to plating rinse waters from plating operations.

The Steam Plant Wastewater Treatment Facility (SPWTF) provides flow equalization, pH adjustment, chemical precipitation, clarification, and sludge dewatering to coal pile runoff, ion-exchange regeneration wastewater, boiler blowdown, and demineralizer waste. The wastewater, which is considered to be RCRA-hazardous prior to treatment, is rendered nonhazardous by the SPWTF and discharged to East Fork Poplar Creek.

RCRA hazardous/mixed

The East Chestnut Ridge Waste Pile is a lined waste pile with leachate collection used for the storage of contaminated soils and spoil materials.

Kerr Hollow Quarry was used for the disposal of water-reactive and shock-sensitive chemicals. The facility is currently being closed.

The RCRA Staging and Storage Facility is a compartmentalized warehouse used for the staging of RCRA wastes before off-site shipment.

The Salvage Yard Oil/Solvent Drum Storage Area (OD2) was a diked storage area where drums of oils and solvents were staged pending disposal. An approved RCRA closure has been performed on this facility.

Security pits were deep trenches used for disposal of classified wastes. Hazardous materials were disposed in this facility prior to 1984. This facility has closed under RCRA guidelines.

Building 9720-9 is a warehouse used for storage of flammable, as well as nonflammable, hazardous waste.

The Interim Storage Yard is a gravel storage yard used to store drums of hazardous waste pending final disposition. A small portion of the yard has been closed in accordance with a TDC-approved closure plan.

The Biodenitrification Facility uses biodenitrification reactors and recovery/feed tanks to biologically denitrify uranium-contaminated liquid wastes.

The Waste Coolant Processing Facility (WCPF) is a biodegradation and storage facility for waste coolants.

The West End Treatment Facility (WETF) is a wastewater treatment facility designed to biologically denitrify nitrate-bearing liquid wastes and to physicochemically treat the resulting solutions to remove inorganic contaminants. Unit operations at WETF include pH adjustment, degassing to precipitate uranium, precipitation to remove heavy metals such as nickel and zinc, and carbon adsorption. WETF treats approximately 1 million gallons of wastewater per year. Effluent from WETF is discharged to East Fork Poplar Creek.

The Central Pollution Control Facility (CPCF) is a wastewater treatment facility that employs physicochemical unit processes to remove oil and grease, heavy metals, and trace organics from non-nitrate bearing wastewaters generated at the Y-12 Plant.

Building 9212 Tank Farm consists of tankage used to store acid and caustic wastes.

The Waste Oil/Solvent Storage Facility is a tank facility that provides 200,000 gal of bulk storage for uranium-contaminated oils and solvents and PCB-contaminated materials, as well as nonuranium contaminated materials.

The Liquid Organic Waste Storage Facility is a bulk and drum storage facility that provides 113,562 L (30,000 gal) of bulk storage and storage for about 300 drums of solvents.

PCBs and PCB/uranium

Oil Drum Storage Area OD3 has two 22,712-L (6000-gal) tanks, which were used to store PCB-contaminated oils. These tanks are part of a larger area that also contained drums. All of the site has been closed with the exception of the tanks.

Building 9418-9 contains a 10,000 gal tank used to contain PCB-contaminated oil pending off-site shipment.

Oil Dike Area (OD-9) has three 40,000 gal tanks that are used to store PCB/uranium-contaminated oil awaiting shipment to the K-25 incinerator for disposal.

The Garage Oil Storage Tanks are 37,854- and 75,708-L (10,000- and 20,000-gal) underground tanks that formerly contained PCB-contaminated oil. The tanks have been drained and removed from the ground as part of the closure plan initiated in 1989. Closure has not been completed.

Building 9404-7 is a warehouse used to store drums of PCB- and PCB/uranium-contaminated wastes.

Building 9720-9 is a warehouse used to store PCB-contaminated waste and RCRA wastes pending off-site shipment.

The Environmental Improvements Line Item project funded the construction of a PCB Staging/Storage Facility to temporarily store drained electrical transformer carcasses and PCB fluid prior to off-site shipment for disposal. This facility consists of a diked concrete pad, pre-engineered roof structure, and plastic walls. The facility was designed for compliance with PCB storage requirements as addressed in 40 CFR 761.

Low-level radioactive

Bear Creek Burial Ground, a shallow land burial facility, has been used primarily for the disposal of low-level uranium-contaminated waste, although it has received RCRA and TSCA wastes. During 1990, only low-level uranium-contaminated trash (including asbestos and beryllium oxide), construction debris, fines, laboratory samples, and miscellaneous uranium metal and alloys were disposed of in the burial ground. Depleted uranium machine turnings were diverted from the burial grounds. The facility is operated in accordance with Report Y/IA-169, *Design and Operating Plan for the Extension of Y-12 Plant Burial Ground A for the Disposal of Low-Level Radioactive Solid Waste*. Operation of this facility is scheduled to cease in June 1991.

Closure activities began in November 1988 on many of the areas used for disposal of RCRA and TSCA wastes; these activities continued through 1990. In addition, a Best Management Plan, Y/IA-210 *Best Management Practices Plan for Waste Management Activities in the Bear Creek Burial Grounds*, has been prepared, and identified activities are being implemented. The objective of these actions is to eliminate disposals in BCBG. Some of these actions were initiated in 1987 and include volume reduction of some solid wastes and subsequent shipment to the K-25 Site for storage.

The Uranium Oxide Vaults (S-114) are two concrete vaults used for the storage of uranium oxide and metals.

The Waste Feed Preparation Facility is a compaction/baling facility that compacts solid, uranium-contaminated wastes into bales for interim storage at the K-25 Site.

The Trash Monitoring Facility is an external radiation monitoring facility that is used to select the proper disposal facility for bulk solid wastes.

8.3.2.2 Oak Ridge National Laboratory

RCRA-regulated and PCB wastes are managed in storage facilities until they can be shipped off site for treatment and/or disposal. Martin Marietta Energy Systems policy defines any material containing greater than 2 ppm PCB as PCB waste. Several facilities operate under interim status while permit applications are under review by TDC. The Hazardous Waste Storage Facility, Building 7652 permit application was approved by TDC in October 1986. PCB-contaminated hazardous wastes are temporarily stored at Building 7507, and PCB-contaminated mixed waste is stored on the 7507W Storage Pad. TRU waste is stored in the TRU Retrievable Storage Facilities, 7855, 7834, and 7823.

Few hazardous wastes are treated in on-site facilities. The Chemical Detonation Facility processes small amounts of wastes that would be dangerous to transport off-site. Explosives such as aged picric acid are detonated in the detonation facility.

The landfill receives nonhazardous industrial materials such as fly ash and construction debris. SWSA 6 receives low-level solid radioactive waste, including radioactively contaminated asbestos. Asbestos and general refuse are managed in the Y-12 Plant Sanitary Landfill.

RCRA designates satellite accumulation areas as those at the site of small-quantity waste generation where wastes are accumulated by the generator to a sufficient quantity to be transferred to a permitted storage facility. Satellite accumulation areas may not receive wastes from other sources. Satellite accumulation areas are used throughout ORNL for hazardous and radioactive waste accumulation. Once a drum is filled, it is transferred to the appropriate storage or disposal facility within 3 days.

8.3.2.3 K-25 Site

The K-770 scrap metal storage facility consists of a 2.8-ha (6.9-acre) tract of land used for storing low-level radioactively contaminated scrap metal. Ferrous and nonferrous materials are generated at the K-25 Site and transported to the storage yard.

The K-770 clean scrap yard provides storage for nonradioactive scrap metal. The scrap metal is stockpiled at K-770 before being sold to the public.

The K-726 PCB storage facility is located inside the K-770 scrap yard. This facility consists of a diked concrete block building with approximately 225-m^2 (2430-ft^2) storage space and is used primarily for the storage of low-level uranium-contaminated PCB waste that may also contain combustible and/or flammable liquids. The current management scheme for these wastes is treatment at the K-1435 incinerator.

The K-306-1 PCB storage facility is a 288-m^2 (3110-ft^2) area used for radioactively contaminated PCB waste. These wastes are also designated for treatment at the K-1435 incinerator. When the PCB waste is removed, this facility will be used for storage of RCRA waste sludges generated at the Y-12 Plant.

The K-311-1 container storage area provides storage for approximately 51 tons of lead wastes generated during previous Y-12 Plant operations. This facility is a 225-m^2 (2400-ft^2) enclosed building. Stored wastes include lead ingots, lead slag, and lead carbonate contaminated with low-level radioactive contaminants.

The K-1419 sludge fixation facility is used for mixing hazardous and mixed inorganic wastes with concrete to form a solid mixture that can be stored aboveground at K-1417. The facility consists of a storage tank area for wastes and a series of storage tanks for nonhazardous feed materials, feed tanks, and mixers. The waste sludges and liquids are mixed with cement and fly ash according to the fixation recipe to stabilize them. The fixation recipes are specific for each waste type.

The K-1417 casting and storage yard, which has a storage area of 1.2 ha (3 acres), is used for storage of drummed solidified sludges generated at the K-1419 facility. Casting activities can be performed either at K-1419 or in the casting area of K-1417. A truck and equipment washing system collects runoff and spillage from the casting area.

The K-306-1 vault 23A hazardous waste storage facility provides storage capacity for about 3000 208-L (55-gal) drums and is used primarily for storing sludges generated during treatment of Y-12 Plant wastewaters at either K-1232 or Y-12 Plant facilities. The drums are sealed, labeled, identified, and inventoried either before or immediately following transport to K-306-1, vault 23A.

The K-305-6 vaults 19 and 19B hazardous waste storage facility offers a storage capacity for 8050 208-L (55-gal) drums. This facility is also used primarily for the storage of sludges generated during the treatment of Y-12 Plant wastewaters at either K-1232 or Y-12 Plant facilities. The containers are sealed, labeled, identified, and inventoried either before or immediately following transport to K-305-6.

The K-1420-A flammable waste storage tank is a 113,562-L (30,000-gal) tank that was modified to store low-flash-point and high-vapor-pressure wastes. The waste types stored in this facility include flammable solvents, gasoline, and paint waste. Only drummed waste that has been identified can be stored at this facility. The waste stored in this tank at the present and in the future will be disposed of at the K-1435 incinerator.

The K-1425 waste oil/hazardous waste/PCB storage facility consists of container and tank storage areas. The container storage building capacity is 480 208-L (55-gal) drums, and the tank storage area consists of four 85,275-L (22,500-gal) tanks in a dike. Wastes stored in this facility include oils, solvents, water, and organics. These wastes may be regulated RCRA, contain PCBs, and/or be radioactively contaminated. Wastes stored in this facility are and will be treated at the K-1435 incinerator.

The K-1435 TSCA Incinerator consists of storage tanks, dikes, and the incinerator. The maximum storage capacity for waste is 1,040,208-L (55-gal) drums. The tank storage capacity is 3.48×10^5 L (0.9×10^5 gal). The incinerator system consists of a liquid, solid, and sludge feed system; a rotary kiln incinerator; and a secondary combustion chamber.

The wastes treated at this facility include oils, solvents, chemicals, sludges, aqueous waste, and solids. The majority of waste treated at the K-1435 incinerator cannot be treated by commercial incinerators because of radioactive contamination. All waste sent to K-1435 for incineration must be fully characterized and identified. DOE has approved a chain-of-custody system for all waste received from off-site.

During 1988, the performance test of the K-1435 TSCA incinerator was completed and shakedown testing was begun. These tests continued through 1989. The incinerator began burning wastes in 1990.

The K-1302 gas cylinder storage facility has been designated for storage of compressed gas cylinders. These gases are commercial products that are to be discarded or treated. The facility has a maximum storage capacity of about 100 ft^3 (2.8 m^3) of gas.

The K-1036-A storage dike is used for waste oil storage. These oils have recently been determined to be regulated by RCRA, and radioactive contamination may be present. This facility has a maximum waste storage capacity of about 2,000,208-L (55-gal) drums. After proper characterization, this waste is designated for treatment at the K-1435 incinerator.

Low-level storage vaults used for storage of nonhazardous radioactively contaminated waste generated at the K-25 Site include K-303-5, K-309-2, and Vault 15A. The K-310-3 low-level storage vault is used for storage of nonhazardous radioactively contaminated waste generated at the Y-12 Plant. The K-310-2 low-level storage vault is used for storage of nonhazardous radioactively contaminated waste generated at ORNL. Vault 15A may also be used for storage of nonhazardous radioactively contaminated waste from ORNL and Y-12.

The K-711 storage facility has a maximum storage capacity of about 1800 208-L (55-gal) drums. The majority of the wastes stored at K-711 have been designated for treatment at the K-1435 incinerator, and primarily consists of waste oils and solvents generated at the DOE facility at Fernald, Ohio, and other DOE facilities.

The K-1202 storage tank facility is used for storage of flammable or nonflammable RCRA regulated liquids that are radioactively contaminated. These wastes are designated for treatment at the K-1435 TSCA Incinerator.

The K-1025-C storage facility is used to store out-of-date or off-specification laboratory chemicals that will be disposed of through off-site commercial facilities. These wastes may be either RCRA or non-RCRA, but must be nonradioactive and non-PCB wastes approved for off-site disposal.

K-310-1 vault in the K-25 building is used to store RCRA regulated sludges and ash from the operation of the K-1035 incinerator.

K-302-4, Vault 8, is being used for storage of RCRA and mixed wastes from K-25 and Y-12.

Vault 8A HW storage is located in the K-25 Building at the K-25 Site and is approximately 350 by 50 ft in area. It is used for the storage of hazardous wastes from K-25 and Y-12.

K-301-1 Vault 4 is approximately 200 ft by 58 ft in area and is divided into three even sections. An 8-inch curb runs between the sections, as well as along the perimeter of the unit, to contain any spills or leaks that may occur. The three individual sections are dedicated to storage of laboratory waste acids, laboratory waste bases, and laboratory waste organics.

K-301-1 Vault 4A is approximately 170 ft by 58 ft in area. An 8-inch curb runs along the perimeter of the unit to contain any spills or leaks that may occur. The waste streams in this vault consist of sludges and incinerator ash.

K-301-2 Vault 4B is approximately 200 ft by 58 ft in area. An 8-inch curb runs along the perimeter of the unit to contain any spills or leaks that may occur. The waste streams in this vault consist primarily of photographic waste (fixer, developer, and toner) and incinerator ash.

K-303-4 (Vault 10B) is approximately 360 ft by 58 ft in area and is used for the storage of PCB-contaminated soil and Zorbal. An 8-inch curb runs along the perimeter of the unit to contain any spills or leaks that may occur.

Prior to startup of the West End Treatment Facility (WETF) and the Central Pollution Control Facility (CPCF) at the Y-12 Plant, significant flows of Y-12 Plant wastewater were processed at the K-1232 Treatment Facility. Currently, a limited amount of treatment of K-25 wastewater is occurring at the K-1232 facility, but additional K-25 waste streams are being identified for subsequent treatment. The K-1232 facility provides for chemical precipitation and pH adjustment of wastewaters. The treatment process takes place in tanks to which various feed chemicals are added and mixed with the wastewaters. The waste is then dewatered through centrifugation and the leachate is trucked to the K-1407-H CNF. When the facility was used for treatment of Y-12 Plant waste streams the settled sludges were collected, dewatered, drummed, and transported to RCRA storage facilities on-site, and the liquid effluent was discharged from the lagoons through an NPDES discharge point located at the K-1203 Sewage Treatment Facility. The K-1203 NPDES permit does not accommodate the source streams that are presently being treated at the K-1232 facility, BMP wastes and K-1420 plating wastes, and therefore, all discharges must currently pass through the CNF.

The facility consists of a drive-through building, with processing tanks located on the north side and centrifuges and other process tanks located on the south side, and external, inground concrete tanks, K-1232-A, -B1 and -B2, and -C, plus above-ground and diked tanks K-1232 -D, -E, -F, and -F-114.

The K-1407-H Waste Treatment Facility (WTF), or the CNF, provides pH adjustment and chemical precipitation for several aqueous streams throughout K-25. The main purpose of the CNF is to treat wastewater to ensure compliance with the requirements of NPDES discharge limits on pH, heavy metal concentrations, and suspended solids. The treatment system consists of two 25,000-gallon reaction tanks and a 60,000-gallon sludge-thickener tank. Acidic wastes are neutralized with a

Table 8.6. K-25 Site on-site waste treatment data for 1990

Type	Quantity (gal)	Treatment	Residue type	Quantity (gal)
Nonhazardous	11.5×10^7	Neutralization	None	
Hazardous	1.8×10^6	Neutralization Metal precipitation	Hazardous sludge	12,100
RCRA/TSCA	29.5×10^4	Incineration	Ash	

hydrated-lime slurry, and basic wastes are neutralized with sulfuric or hydrochloric acid. The hydrated lime bin and acid tanks are located at the facility. Waste streams from K-1401, K-1420, K-1435, K-1501, and miscellaneous laboratories and process operations are received at the CNF. Most of the radioactively-contaminated wastewater treated at the CNF is generated at the K-1420 Uranium Decontamination Facility where equipment that was used in the gaseous diffusion and development facilities and that gradually accumulated uranium-bearing compounds during operation is decontaminated to meet radiation standards. Treated effluents are discharged through the K-1407-J NPDES point. The contaminated sludges that precipitate in the sludge-thickener tank will be stored in an approved aboveground storage area at K-25. The CNF is physically divided into two distinct sections for treating both hazardous and non-hazardous waste streams.

8.3.3 On-Site Treatment

Compaction/baling of solid, low-level, and uranium-contaminated wastes from Y-12 is conducted at the Waste Feed Preparation Facility.

Dewatering is being made available for storm sewer sediments at the Sludge-Handling Facility, for nonnitrate waste sludges at the CPCF, and for nitrate waste sludges at the WETF.

Wastewaters generated at Y-12 are typically treated at the West End Treatment Facility, the Central Pollution Control Facility, the Steam Plant Wastewater Treatment Facility, or the Waste Coolant Processing Facility (WCPF). The WCPF is designed to biologically degrade machine cutting coolants. Effluent from the WCPF is taken to the CPCF or WETF for final treatment and discharge.

Oxidation of uranium machine turnings is performed at the Chip Oxidation Facility.

The on-site waste treatment quantities at the Y-12 Plant are shown in Table 8.1 of Vol. 2.

On-site treatment at ORNL includes elementary neutralization and detonation facilities and mercury and silver recycle units. Quantities and types of wastes processed at ORNL during 1990 are presented in Table 8.2 of Vol. 2.

On-site treatment facilities at the K-25 Site include the K-1435 TSCA Incinerator, K-1407-N Central Neutralization Facility (CNF), K-1419 sludge fixation, K-1232 treatment, and K-900 bottle smasher. See Sect. 8.3.2.3 for descriptions of these treatment units. Quantities and types of waste treated at these facilities are shown in Table 8.6.

Treatment of the current inventory of contaminated scrap metal at the K-25 Site (as well as Portsmouth, Paducah, and Fernald DOE facilities) is expected to occur over the next 3 to 5 years as part of a comprehensive DOE Scrap Metal Program, to be managed through the K-25 Site. Under this program, the scrap metal will be processed for beneficial reuse where possible or size-reduced for disposal.

8.3.4 On-site Waste Disposal Activities

On-site waste disposal quantities for all three plants in 1990 are shown in Tables 8.3, 8.4, and 8.5 of Vol. 2.

The only on-site disposal units for ORNL are the contractor's landfill and SWSA 6.

Currently, there are no on-site disposal facilities being operated at the K-25 Site. The RWMO has been established and assigned the responsibility to design, construct, and operate all new low-level waste disposal facilities for the ORR. The RWMD is physically located at the K-25 Site. The new LLW disposal facilities will be developed in concert with the strategy originally developed by LLWDDD and will serve waste generators from all three DOE facilities on the ORR. The Low-Level Waste Disposal Facilities (LLWDF) project will provide new disposal facilities at a new centralized location of the ORR for BRC, Class L-I, and Class L-II low-level wastes, with capacity up to 40 years to be available. The LLWDF will utilize state-of-the-art disposal technologies, including lined trenches with leachate collection treatment capabilities for BRC/Class L-I wastes and tumulus confinement disposal units for Class L-II wastes. As currently scheduled, these facilities are expected to be operational in 1996.

8.3.5 Off-site Waste Disposal

Incineration is the preferred method for off-site disposal of wastes, particularly PCB wastes; however, landfills and other types of disposal are used as needed. For instance, PCB-contaminated transformer carcasses cannot be incinerated and must be sent to a landfill.

Off-site disposal, as listed in Tables 8.6, 8.7, and 8.8 of Vol. 2, is arranged through the Transportation and Purchasing departments. Unless special circumstances warrant otherwise, all such disposals are awarded to the lowest qualified bidder. Commercial transporters or transportation provided by the disposal firm is used to move the waste from the site. All incoming and off-site shipments of wastes conform to U.S. Department of Transportation (DOT) criteria for such shipments. The criteria include packaging, manifesting, and shipping requirements. All containers must meet DOT shipping requirements. Packages and vehicles are inspected and inventoried before shipment.

Contracts are made only with approved commercial disposal contractors to ensure safe and environmentally sound operations. Contractor approval is based on a site visit and evaluation that includes scrutiny of areas such as financial responsibility, operating procedures, regulatory compliance history, recordkeeping and reporting, training and qualifications, and security and emergency procedures. Each commercial contractor must be evaluated every two years.

Several shipments of scintillation vials from ORNL have been sent off-site for incineration. The vials are used in scintillation counters and contain the radioactive isotope in a mixture of xylene and toluene. With the exception of these scintillation vials, mixed wastes are stored rather than sent off-site for treatment. These scintillation vials were below the Nuclear Regulatory Commission's (NRC's) exclusion limit and were not considered radioactive.

The K-770 clean scrap yard provides storage for nonradioactive scrap metal. The scrap metal is stockpiled at K-770 before being sold to the public.

8.3.6 Waste Placed in Storage

In some cases, wastes cannot be disposed of, either immediately or in the foreseeable future. Storage requirements fall into two categories, short-term storage for those wastes awaiting off-site shipment or treatment, and long-term storage for wastes, such as mixed wastes, that are being stored pending future disposal decision.

Wastes are stored on-site for several reasons. Recyclable materials such as mercury and silver-bearing photographic wastes are stored before recycling, while other hazardous wastes are stored until sufficient quantity is accumulated for an off-site shipment. Mixed wastes are stored until incinerator capacity is available locally to destroy them. Many of these wastes will be treated in the K-1435 TSCA Incinerator, which began operation in 1990.

Information on wastes stored at the three plants is given in Tables 8.9–8.15 of Vol. 2.

SPECIAL STUDIES

9. SPECIAL STUDIES

Many environmentally related special studies are conducted on the ORR annually. This chapter includes those studies that are not directly associated with the annual environmental monitoring activities but may be of special interest to some readers. The studies were submitted for publication by the plant most directly involved with each study.

9.1 Y-12 PLANT

9.1.1 Alternate Concentration Limit Demonstration

An Alternate Concentration Limit (ACL) Demonstration project is being implemented to develop cleanup levels for groundwater at the S-3 Ponds, the Bear Creek Burial Grounds, and the Oil Landfarm WMAs located within the Bear Creek Valley west of the DOE Y-12 Plant, Oak Ridge, Tennessee. The ACL Demonstration utilizes a coupled modeling approach in which a three-dimensional groundwater flow model of the Y-12 facility is used to support more detailed contaminant transport models at the scale of each WMA. These models are used to support risk assessments involving potential contaminant levels in groundwater and surface water.

An ACL demonstration for nitrate, uranium, cadmium, and tetrachloroethene at the S-3 WMA has been documented and submitted to TDC and EPA Region IV for review. The S-3 WMA encompasses the former location of the S-3 Site Hazardous Waste Disposal Unit, a RCRA-regulated unit consisting of four unlined surface impoundments that received liquid waste from 1951 to 1984. It also includes four nearby SWMUs: the Salvage Yard, the Interim Drum Storage Yard, the Rust Garage, and the S-2 Site. The flow and transport models were calibrated by estimating aquifer properties, contaminant source concentrations, and chemical transport parameters.

The result was a three-dimensional distribution of contamination that accurately represented current conditions. Attenuation factors for each contaminant were calculated by modeling the transport of contaminants over time and predicting the concentrations expected at downgradient receptor points. The attenuation factors were then used to calculate groundwater standards at the S-3 Ponds necessary to produce an acceptable risk at the receptor points. This effort will be extended to calculate risk-based cleanup levels for other contaminants of concern.

Similar modeling efforts and risk assessments are planned for the Bear Creek Burial Grounds and the Oil Landfarm WMAs. In addition, sensitivity analysis and further calibrations of the sitewide groundwater flow model are ongoing and will incorporate new groundwater characterization data and interpretations.

9.1.2 Y-12 Spill Report

The Y-12 Plant had a total of 151 recorded spills or releases of various types of materials during CY 1990. This compares with 153 spills or releases recorded during CY 1988, and 103 spills or releases recorded in CY 1989. Of the 151 spills recorded in CY 1990, 51 were reportable under either the Clean Water Act or CERCLA (Figs. 9.1 and 9.2).

As in CY 1988 and CY 1989, many of these spills involved petroleum products (Fig. 9.3). Each recorded spill event was investigated by the Y-12 Plant Spill Coordinator to determine the potential environmental impact caused by the spill, assist with the cleanup of the spill, and suggest ways to prevent the same type of spill from recurring. Cleanup operations were generally performed by trained staff members of the Y-12 Plant Waste Transportation, Storage, and Disposal Department. All cleanup operations and disposals of cleanup materials were handled according to Y-12 Plant standard operating procedures. The Y-12 Plant EMD reports spill events to various levels of Y-12 management, DOE, and other governmental agencies as appropriate.

Several measures have been taken to prevent spills in the Y-12 Plant. Guidelines were developed and implemented in CY 1990 that require secondary containment for materials stored in drums. As part of the revisions to the Y-12 Plant Spill Prevention, Control, and Countermeasures Plan that were made in CY 1990, several tanks and structures were identified that are in need of some type of secondary containment. These conditions will be further assessed and remediation will begin in CY 1991. Also, efforts will be undertaken in CY 1991 to identify transformers that have inadequate or nonexistent secondary containment. Corrective actions for these problems should begin late in CY 1991.

9.1.3 Floodplains and Wetlands Studies

In response to findings from the October 1989 Compliance Assessment (Tiger Team) of the Oak Ridge Y-12 Plant, two special studies were initiated. The studies are focusing on the applicability of the DOE floodplain and wetland review requirements. These requirements are contained in 10 CFR parts 1022.5 and 1022.11.

Energy Systems and DOE-ORO are conducting two separate studies, one addressing wetlands and the other addressing floodplains for areas adjacent to East Fork Poplar Creek and Bear Creek. The studies are determining the location and extent of floodplains and wetlands and will provide baseline characterization data. Documentation of the studies will be developed and included as a new volume in the resource management plan for the U.S. DOE Oak Ridge Reservation, ORNL-6026/V1-17. The floodplains/wetlands location and characterization data in this volume will then be used in siting new facilities and determining the impacts of planned operations or development.

9.1.4 Beryllium Stack Sampling

The need for a Beryllium Stack Monitoring Upgrades Project was identified in 1987. Because the funding for the project was uncertain and the need to reevaluate compliance with TDC regulations existed, the Y-12 Clean Air Program initiated a project to test the beryllium sources at the Y-12 Plant. TDC air permitting regulations specify that a beryllium source

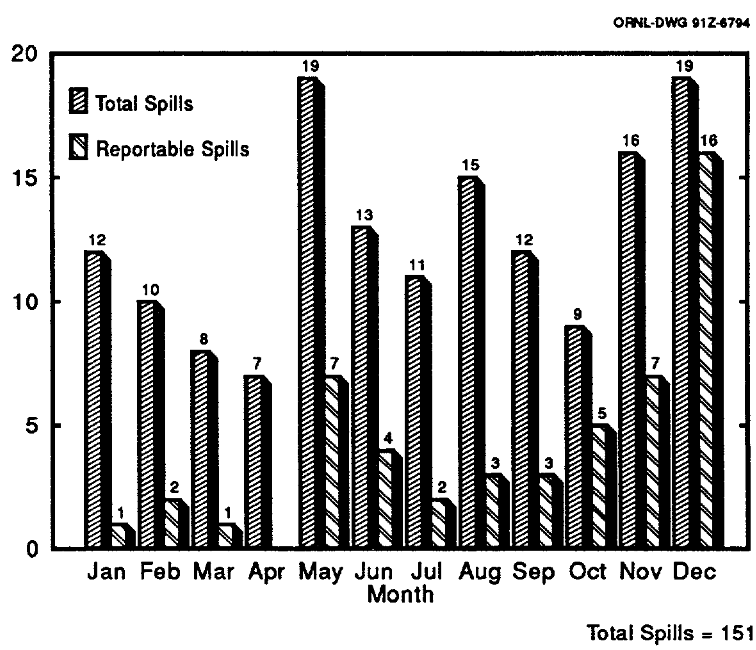


Fig. 9.1. 1990 Y-12 Plant spills summary (including CERCLA and CWA violations).

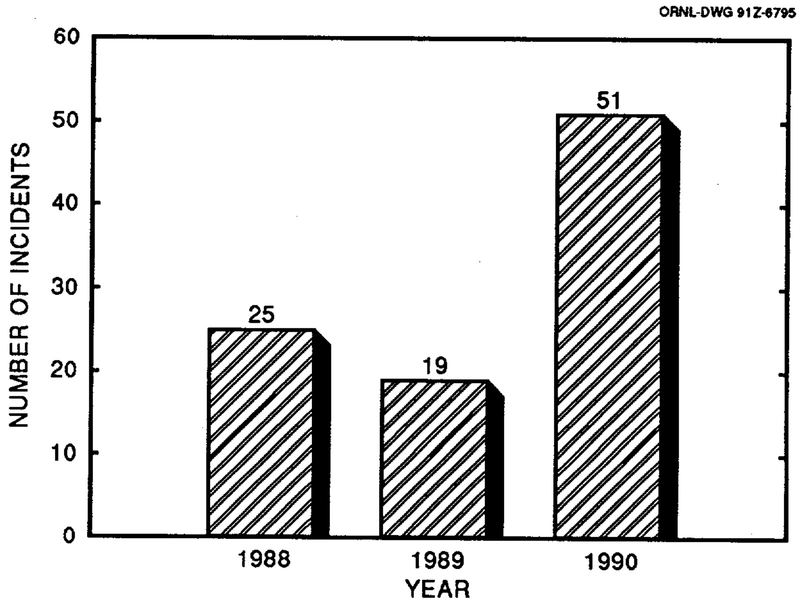


Fig. 9.2. Y-12 Plant reportable environmental releases (including CERCLA and CWA violations), 1988–1990.

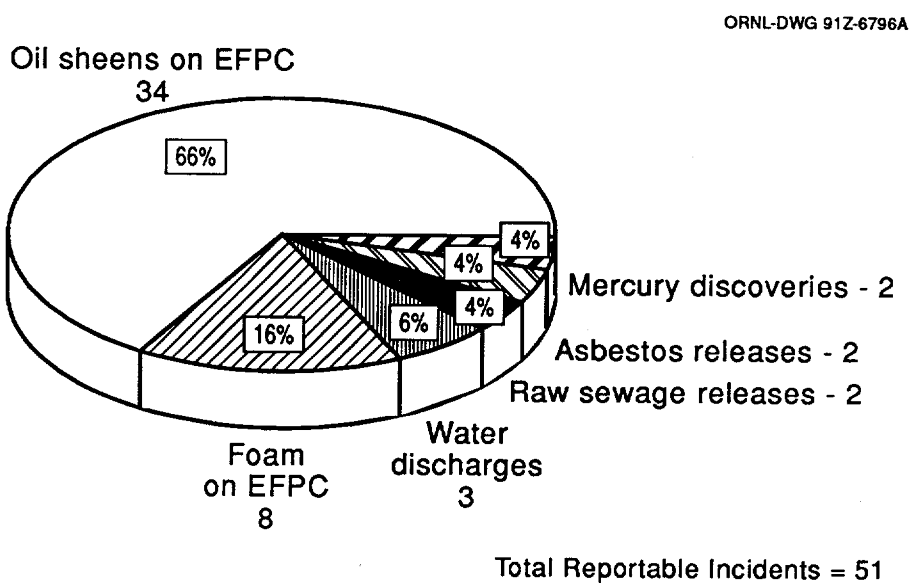


Fig. 9.3. 1990 Y-12 Plant reportable environmental releases (including CERCLA and CWA violations).

is to be tested for compliance under the regulations only once (with the exemption of another possible test if the source is modified). Regulation 1200-3-11-.03(3) (a) states that emissions to the atmosphere from a source (in this case the Y-12 Plant) shall not exceed 10 grams of beryllium during a 24-hour period.

Air stack tests were conducted using EPA Stationary Source Test Method 104, "Determination of Beryllium Emissions." The results from all the beryllium sources tested indicated that the emissions from the Y-12 Plant are less than 3.5 grams per 24-hour period and therefore are in compliance with the TDC regulation. A less-than number is reported because the results of all the individual stack tests were below the detection limits of the laboratory analysis.

9.1.5 Impact of Sulfur Dioxide from the Y-12 Steam Plant on Off-site Elevated Terrain

A report was prepared by the Environmental Compliance Department at ORNL in response to Finding 3.5.1.3.5 of the Tiger Team Assessment of the Y-12 Plant, conducted from September 25 to October 20, 1989. The assessment had found that a dispersion modeling study using up-to-date complex terrain dispersion models had not been carried out to assess the sulfur dioxide ambient impact of the Y-12 Steam Plant on off-site elevated terrain.

The Environmental Compliance Department at ORNL carried out the required modeling studies, which had the performance objective that the Y-12 Steam Plant must not cause or contribute to ambient concentrations of sulfur dioxide that would exceed ambient air quality standards. The results indicate that the Y-12 Steam Plant emissions are not likely to result in exceedances of primary or secondary ambient air quality standards in the high terrain areas.

9.1.6 Identification and Characterization of Storm Drain Outfalls and Processes That Discharge to Surface Waters

A number of outfalls on East Fork Poplar Creek (EFPC) are not specifically listed on the existing Y-12 Plant NPDES Permit and, therefore, are not routinely sampled. These outfalls were included in a list of Category III type outfalls (discharges from buildings and areas with possible process effluents) in a 1983 storm drain system characterization report submitted to the state and EPA as part of the 1985 NPDES permit application. All known sources of Category III type discharges have since been eliminated in the plant. An outfall sampling plan was initiated in June 1989 to recharacterize the discharges from these outfalls. The results from this sampling effort have been incorporated into the recent submittal of the new NPDES permit application. The results obtained indicate that the effluents from these outfalls are similar to a Category II type discharge (cooling water, condensate, precipitation, and building, roof, and foundation drains). A routine sampling program has been initiated for these outfalls, and results will be reported as an attachment to the monthly DMR.

Also, a number of discharges originate from testing and/or processing equipment used in the Y-12 Plant. As part of the recent effort to characterize more completely the miscellaneous source category of the existing NPDES permit, various sources of effluent discharges were identified and included in the NPDES permit application submittal. These sources include ultrasonic test gages and density testing baths used for nondestructive testing of metal parts, photographic units used for processing film, and vapor blasters used to clean metal parts.

Additional efforts are under way to identify any other miscellaneous outfalls that may be targeted for rerouting of water or alternate treatment and disposal. One major finding is that a number of sinks are tied to the storm drain system. The storm drainage system in 74 major process buildings was surveyed in 1989 in an effort to reduce the potential for accidental releases to EFPC. This study has been expanded to include 39 more buildings in FY 1991 and 40 buildings in FY 1992.

The study focuses on characterization and verification of drain routing for all sinks at the Y-12 Plant. The discharges from lavatory sinks are connected to the sanitary sewer, as are many nonlavatory sinks in over 400 buildings within the Y-12 Plant. However, some nonlavatory sinks are tied to the storm sewer system that discharges to EFPC.

Currently, administrative controls in place at the Y-12 Plant prevent disposal of chemicals in sinks. Each division at the Y-12 Plant has at least one Environmental Officer who trains the employees in the proper use and disposal of chemicals and wastes.

Polytanks and/or other containers are now required for routine disposal of chemicals. In addition, substitutions are made whenever a less-toxic chemical can be used to minimize potential effects resulting from spills or inadvertent disposal. The goal of the sink identification project is to identify sinks on building drawings, characterize possible discharges from those sinks, and determine the appropriate routing and/or treatment for that discharge. This major effort will result in all sinks being separated from EFPC.

9.1.7 East Fork Poplar Creek Area Source Pollution Assessment and Control Program

The Y-12 Plant NPDES permit requires evaluation of area source discharges from within and around the plant to determine their impact on the water quality of EFPC. Area source discharges, also referred to as nonpoint source pollution, result when uncontaminated surface water or groundwater flows over or through contaminated surfaces and results in the transfer of pollutants to a receiving stream. To characterize area source discharges into EFPC and to develop a plan for their control, the Y-12 Plant has developed an area source pollution assessment and control plan for EFPC with the assistance of Camp, Dresser, and McKee, Inc.

During the preliminary sampling phase of the EFPC area source pollution assessment program, it was determined that nonpoint source pollution has a significant impact on instream water quality. To quantify pollutant transport into EFPC from area source discharges and to locate sources of these discharges, a comprehensive sampling program was conducted from September 1988 to April 1989. The major goals of this program are to identify locations of potential area source discharges, to determine pollutant loadings from these sources, and to identify appropriate corrective actions. The comprehensive sampling program consisted of flow monitoring and water quality sampling at 12 sites within the Y-12 Plant and within the EFPC drainage basin. Sampling intervals include a number of storm events ("wet weather" samples) as well as sampling during normal flow periods ("dry weather" samples). By comparing the wet weather and dry weather water quality, sources and impacts of nonpoint source pollution can be evaluated. The analysis of samples and evaluation of data are currently being conducted.

In assessing parameters of greater concern in EFPC, those that exceeded applicable water quality standards for multiple events and multiple stations were selected. Seven dry-weather parameters of concern were selected: total residual chlorine, copper, lead, manganese, mercury, nitrate, and total dissolved solids (TDS). The wet-weather parameters of concern are total residual chlorine, copper, iron, lead, manganese, mercury, and zinc. Based upon this initial screening, contaminant loadings to EFPC were calculated.

Six BMPs have been identified. They are (1) a 99% reduction in total residual chlorine loads from all EFPC point source contributions, (2) a 96% reduction in nitrate loads from west groundwater contributions, (3) a 70% reduction in copper loads from west groundwater contributions to EFPC, (4) a 90% reduction in iron loads from all EFPC nonpoint source contributions, (5) a 25% reduction in copper loads from all EFPC nonpoint source contributions, and (6) a 98% reduction in the groundwater mercury loads from the east portion of the plant and a 70% reduction in the nonpoint source contributions to EFPC. Feasibility studies to analyze methods to reduce these contaminants will constitute the next phase of the Area Source Pollution Assessment and Control Program.

9.1.8 Treatment for Category IV Discharges

Category IV discharges are classified as outfalls that contain untreated process water under the Y-12 Plant's current (extended) NPDES permit. The permit requires the application of BMPs to reduce to a minimum the pollutants contained within each discharge. In addition, the permit imposes a TCMP plan on each discharge. If the TCMP demonstrates that wastes are discharged in toxic amounts, then a toxicity control plan is to be developed and implemented.

All 22 Category IV discharges—with the exception of the nine photographic rinsewaters, which are shut down, the Building 9202 Catch Basin, and Sanitary Landfill 2—have been treated or eliminated from discharging to area surface streams. As a result of negotiations with city of Oak Ridge officials, photographic rinsewaters will be sent to the city sanitary sewer treatment facility. All tie-ins are expected to occur in 1991.

The nine photographic processes have shut down operations until the rerouting or elimination has been completed. The catch basin at Building 9202 contains mostly once-through cooling water and steam condensate used in heating. It was originally classified as a Category IV discharge because a few of the laboratory sinks were also connected to the basin. Plans are being formulated for disconnecting all sinks from the storm drain network. Presently, administrative controls are used for managing the sinks. This discharge was reclassified as a 700 Series—Miscellaneous Source Discharge in the November 1989 NPDES application. The justification for this change was based on the strict administrative controls and the negative toxicity results based on numerous toxicity tests conducted between 1985 and 1988. Sink reroutes are expected to be conducted during FY 1991 and FY 1992 (refer to Section 9.1.6). The precipitation runoff from Sanitary Landfill 2 has also been reclassified in the NPDES permit application based on chemical analysis and toxicity tests that have not demonstrated any significant contamination.

9.1.9 Chlorine Reduction Feasibility Study

The Y-12 Plant has numerous once-through cooling units used in several plant processes and 18 cooling towers that contribute to the EFPC flows and low contaminant loading. Based on preliminary flow balance calculations of the Y-12 discharges to EFPC, the once-through cooling units and cooling towers contribute over 70% of the dry-weather flow monitored at EFPC, of which over 60% can be attributed to once-through cooling water. The sources of once-through cooling water are variable discharges located throughout the storm drain system.

The purpose of this study is to investigate the most significant potential sources of residual chlorine and to evaluate alternatives that effectively reduce chlorine residual levels to water quality criteria at EFPC. The installation of the first chlorine removal treatment system is planned in 1991 at one outfall, with several additional creek outfalls to be treated in the future based on continued feasibility assessments. The treatment system is envisioned as a carbon absorption or chemical addition station, based on the most feasible site-specific design. Small units on influent cooling water lines may be included at several plant or process locations. Addition of recirculatory systems to replace once-through systems will be part of a 1992 phase in this project.

9.1.10 Aquatic Life Survey

A surveillance program of EFPC to assess the physical condition and mortality of aquatic life was initiated on July 18, 1990, and extended through the calendar year into 1991. As a result, several related studies were begun and are progressing in an effort to extract causes contributing to adverse impacts on the stream aquatic life. Personnel from the Environmental Sciences Division at ORNL, the Environmental Management Department at the Y-12 Plant, several Y-12 operations groups, and various other industry consultants outside the ORR have contributed to this undertaking. Among the studies being performed are assessments in the areas of pathology and toxicology.

The program includes routine visual inspections on a daily basis, excluding holidays and weekends, that topographically follow the EFPC from Bear Creek Road through the diversion channel to the North/South pipes. In addition, water sampling at various sites along EFPC has been enacted to monitor the water quality, with heavy emphasis being placed on chlorine, pH, temperature, ammonia, and dissolved oxygen. A review of the data has not identified any toxic substance or cause other than chlorine.

Included in the numerous ongoing actions underway to determine the cause of adverse impacts are (1) the formation of a committee to review plant discharges, (2) continuance of the Biological Monitoring and Abatement Program and the Toxicity Control and Monitoring Program, (3) a chlorine reduction feasibility study, (4) a drain/source survey, and (5) an in-depth streamside survey studying the toxicity of chlorine in the creek as it applies to aquatic life.

9.1.11 Rogers Quarry Effluent Quality

Rogers Quarry has been used for the disposal of coal fly ash and bottom ash from the Y-12 Steam Plant since 1965. The Y-12 Plant is implementing alternative coal ash disposal methods to eliminate the discharge of ash slurry to McCoy Branch (upstream of Rogers Quarry) and Rogers Quarry. In 1990, these methods included the interim measure of burning 80% natural gas instead of coal at the steam plant and the extension of the ash sluice pipeline directly to

Rogers Quarry, thereby bypassing McCoy Branch. The pipeline extension went into operation in November 1989.

The interim measure of burning less coal was expected to result in some improvement in the effluent quality of Rogers Quarry, especially concentrations of sulfate, arsenic, and selenium that may be released from coal ash. Average concentrations of these constituents decreased significantly in the quarry effluent during 1989, the first full year of burning 80% natural gas instead of coal. Average concentrations of those same parameters showed only a slight decrease in 1990; however, turbidity levels were also lower in 1990 than 1989.

Most significantly, the discharge of fly ash to Rogers Quarry was discontinued in May 1990 upon completion of the Fly Ash Handling Facility. Fly ash makes up 80% of total ash production. Efforts are under way to eliminate bottom ash by 1993.

Monitoring of the effluent of Rogers Quarry will continue as progress on the complete elimination of the ash slurry is made. In addition, water balance monitoring will be continued. Biological monitoring of McCoy Branch, both upstream and downstream of Rogers Quarry, which began in 1989, will continue to document recovery.

9.2 OAK RIDGE NATIONAL LABORATORY

9.2.1 Miscellaneous ORNL Spills

During 1990, ORNL had a total of 135 spills or releases of various types of materials compared with 109 for 1986, 92 for 1987, 119 for 1988, and 91 for 1989 (Figs. 9.4–9.10). ORNL has defined a spill as any material outside its containment vessel. A spill is not necessarily a release to the environment; it may be to the floor, a laboratory bench, or a secondary containment structure. Emphasis is placed on spill reporting and investigation to prevent any environmental releases. Members of the ORNL Office of Environmental Compliance and Documentation investigated each spill or release to determine the environmental impact, to provide input for reducing any harmful effects, and to assist with cleanup efforts. Cleanup activities were conducted by staff members of the ORNL Hazardous Waste Operations Group. All cleanup materials were disposed of according to ORNL procedures.

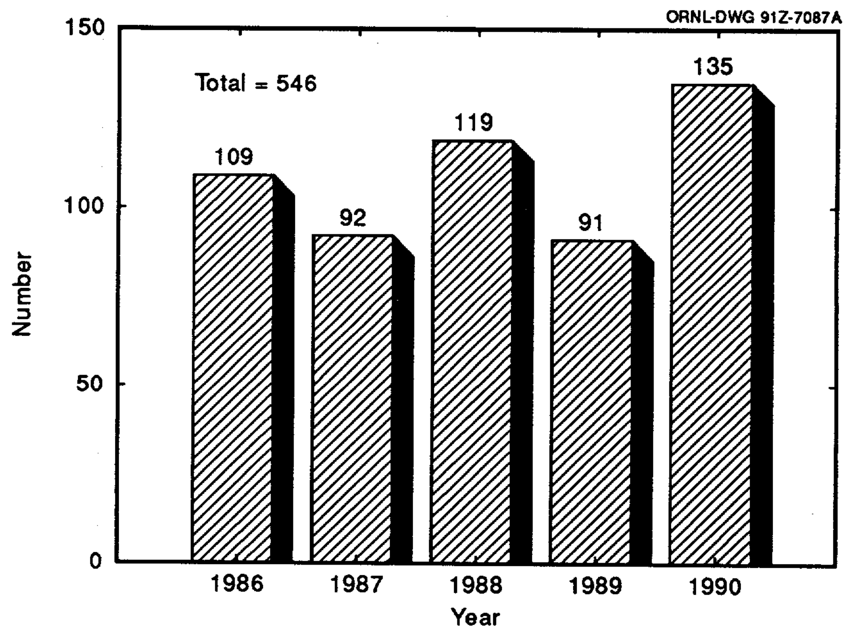


Fig. 9.4. ORNL spill summary, 1986–1990.

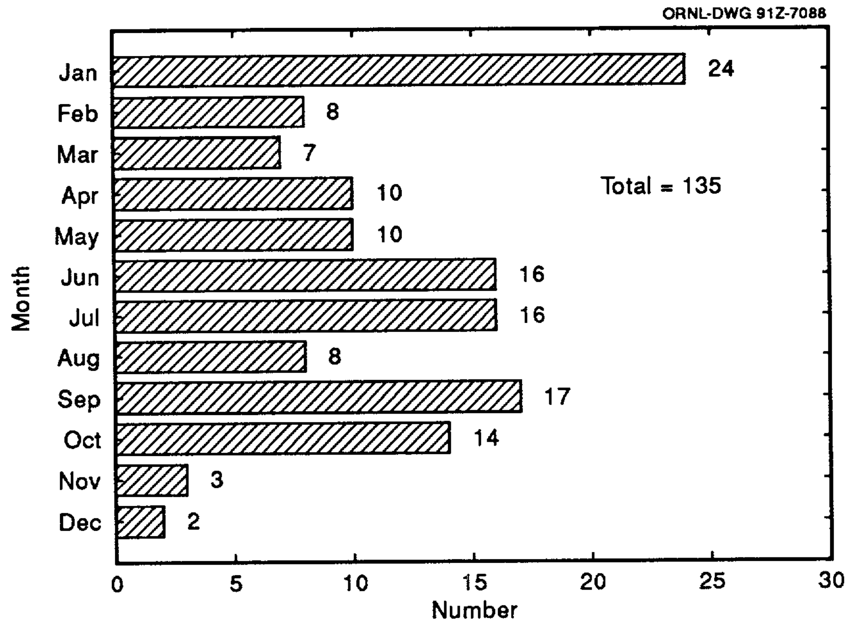


Fig. 9.5. 1990 ORNL spill summary (monthly frequency).

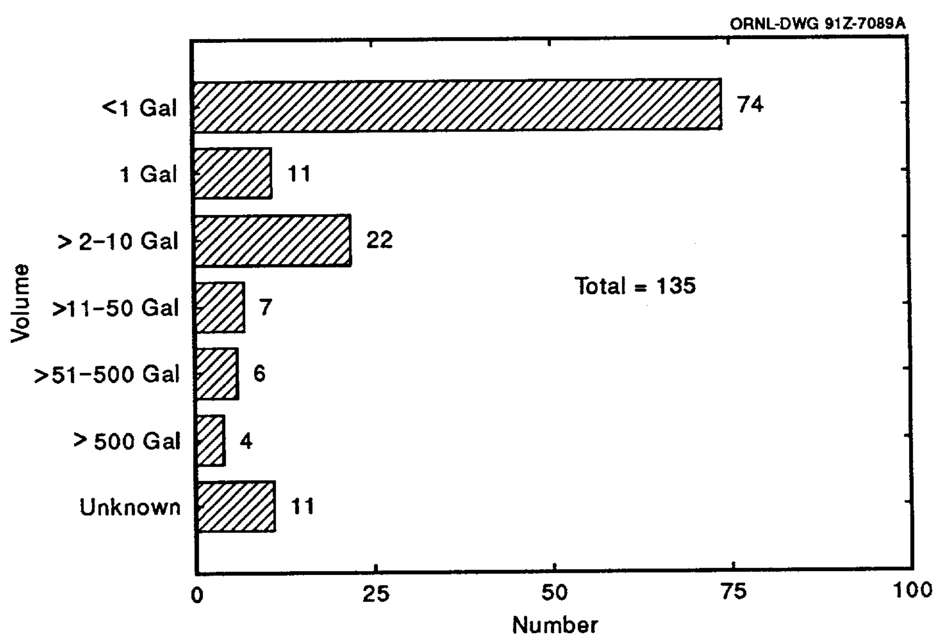


Fig. 9.6. 1990 ORNL spill summary (volume frequency).

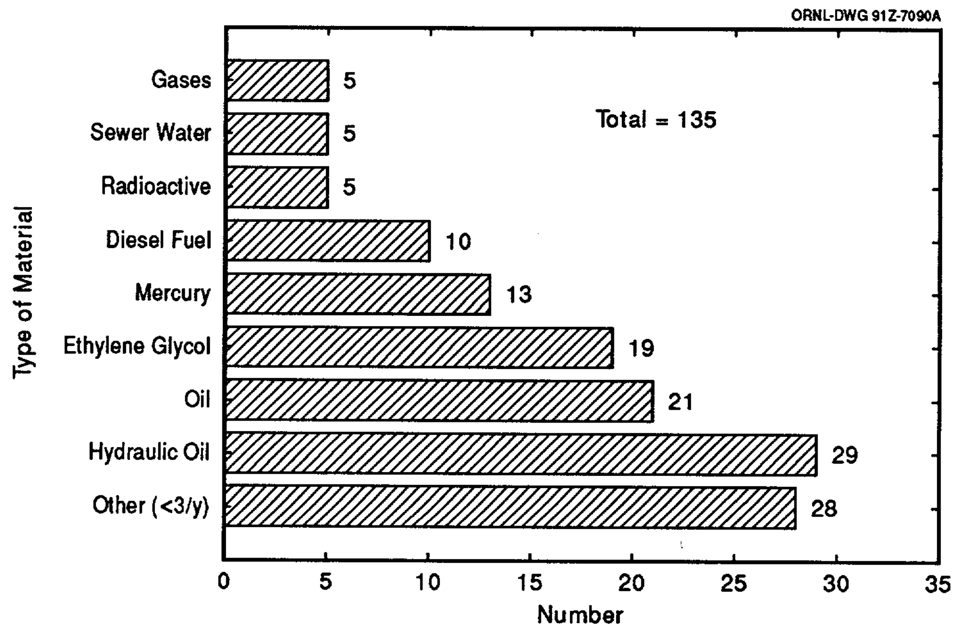


Fig. 9.7. 1990 ORNL spill summary (material frequency).

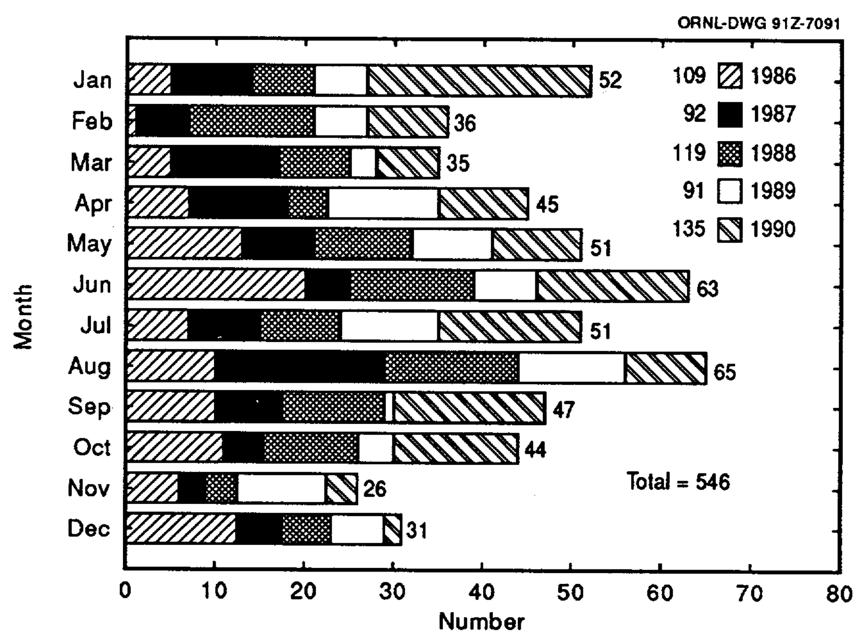


Fig. 9.8. ORNL spill summary, 1986–1990 (monthly frequency).

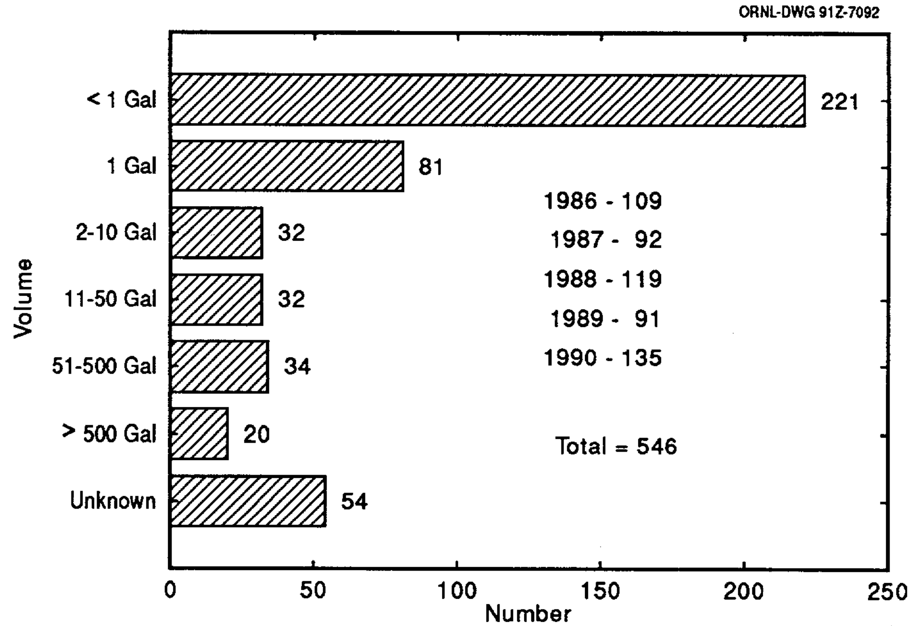


Fig. 9.9. ORNL spill summary, 1986–1990 (volume frequency).

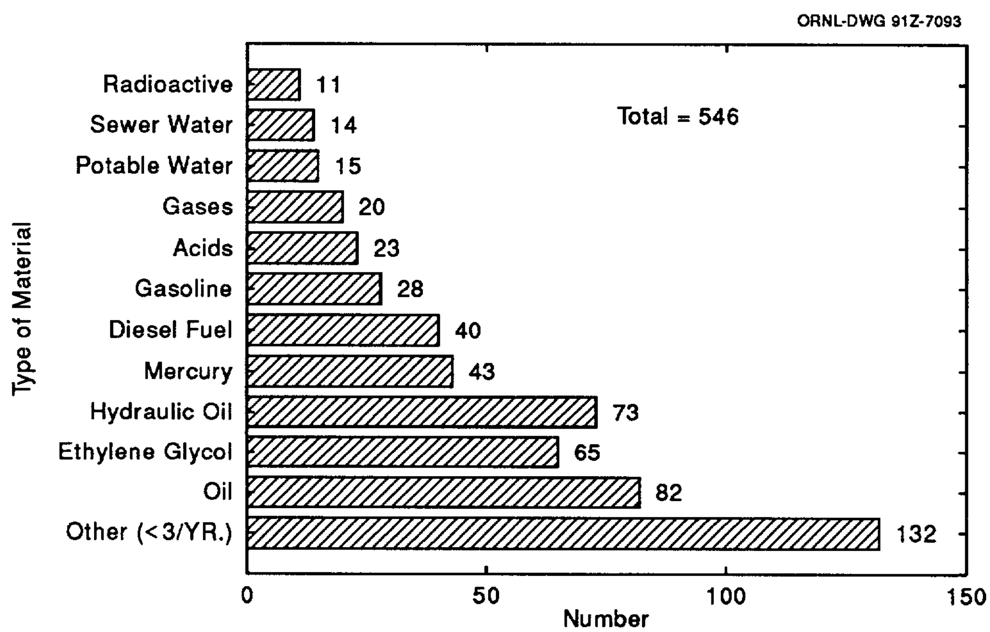


Fig. 9.10. ORNL spill summary, 1986–1990 (material frequency).

ORNL reports all spills via the electronic mail system to various levels of ORNL management as soon as possible after the spill; updates are provided as necessary. This reporting system has resulted in an increased awareness of spills by ORNL staff members. Additional reporting, if required, is done under ORNL Occurrence Reporting System as required by DOE Order 5000.3A, *Occurrence Reporting and Processing of Operations Information*.

As in previous years, many of the spills involved petroleum products. Efforts to enhance spill prevention, especially of petroleum products, included training for more than 900 ORNL Plant and Equipment Division personnel and increased monitoring of construction activities and storage areas where these types of spills often occur. The monitoring and site assessment activities, conducted by Field Interface Staff, also provided an opportunity to detect and prevent other potential environmental problems. Of the 135 spills, 74 were less than a gallon in quantity, and 4 were greater than 500 gallons.

9.2.2 Discovery of Contaminated Surface Sediment in White Oak Creek Embayment

In fulfilling the requirements of the Clinch River RFI Phase-1 sampling plan, a sediment core was collected in late June 1990 from the lower portion of the White Oak Creek Embayment (WOCE), approximately 50 yd upstream from the mouth of WOC. This core was analyzed for ^{137}Cs activity, and the analytical results became available in late August 1990.

Examination of the analytical data revealed that this core sample contained 45,000 pCi/g dry wt. of ^{137}Cs at the sediment surface. This level of activity was surprisingly high, and it was rechecked to verify its accuracy. Thirty-one surface-sediment grab samples were collected on August 30, 1990, and analyzed for ^{137}Cs activity to determine the spatial extent of the contamination in the lower WOCE. Results of these analyses confirmed that relatively high levels of ^{137}Cs activity (ranging from <3,000 to about 20,000 pCi/g dry wt.; average = about 10,000 pCi/g dry wt.) existed in the surface sediments of the lower embayment.

Such levels of ^{137}Cs activity at the sediment surface produced immediate concern because surface sediments in the WOCE are uncontrolled (i.e., surface sediments can be readily eroded from the embayment and transported downstream into the Clinch River). On September 7, 1990, an Occurrence Report was filed, and regulatory agencies were subsequently notified of the occurrence of contaminated surface sediment near the mouth of White Oak Creek. Additional surface-sediment grab samples were collected from the WOCE on September 18, 1990, and analyzed for ^{137}Cs activity. An inventory of ^{137}Cs based on the August 30 and September 18 grab samples (total of 72 sediment grab samples) indicates that between 3 and 4 curies of ^{137}Cs reside in the upper 5 cm of WOCE surface sediments.

The available data indicate that at least three mechanisms of sediment erosion and transport are operating in the WOCE: (1) the normal upstream to downstream erosion and transport of particles from the upper WOCE to lower WOCE; (2) sediment focusing from shallower (upper WOCE) to deeper (lower WOCE) areas; and (3) sediment erosion and transport from lower WOCE enhanced by the surging of water in and out of the WOCE as a result of peaking power operations at Melton Hill Dam, located CRM 23.4 km upstream on the Clinch River.

A comparison was made of the sediment profiles of ^{137}Cs obtained from the WOCE since the late 1970s (Oakes et al. 1982, TVA 1986, and the Phase-1 core obtained in Summer 1990). This comparison indicates that while the sediment stratum containing the highest concentrations of ^{137}Cs (corresponding to the mid-1950s release from White Oak Lake) has previously occurred at sediment depths from 30 to 60 cm (Oakes et al. 1982, TVA 1986), this stratum is now exposed at the sediment surface in the lower portion of the WOCE just upstream from the mouth of WOC. The interpretation is that the layer of less contaminated sediment, which has previously overlain the highly contaminated stratum, has been gradually removed by erosion and transport accelerated by the cyclic surging of flow that occurs twice daily in the lower WOCE.

Melton Hill Dam, a Tennessee Valley Authority hydroelectric-power dam, is located on the Clinch River (at CRM 23) just upstream from the mouth of White Oak Creek. This dam, which began operations in 1963, is used as a peaking-power unit and usually generates twice each day for 1 to 2 h. Generation of electricity at the dam results in the release of water downstream that increases the water level at the mouth of WOCE by about 0.6 m (2 ft) and results in an upstream surge of water into the lower WOCE. When peaking power production ceases, the water level again drops, and water rapidly drains from the lower WOCE into the Clinch River.

Sediment samples obtained in depositional areas in the Clinch River downstream of the mouth of WOC contained relatively low concentrations of ^{137}Cs. However, the concern is that the contaminated surface sediment located in the lower WOCE could be readily transported from the embayment into the Clinch River.

A recommendation was made that an immediate corrective action is required to control the WOCE sediments and to prevent the transport of contaminated sediments from the ORNL area into the off-site surface water environment. DOE, EPA Region IV, TDC, the U.S. Corps of Engineers, and TVA have agreed that the provisions of CERCLA 121(e) are to be invoked to permit initiation of a time-critical corrective action to prevent the potential transport of contaminated sediment from the WOCE to the Clinch River.

9.2.3 Subsurface Stormflow

Research has recently been conducted to determine the importance of subsurface stormflow to hydrologic processes in the ORNL area. Stormflow zones approximately correspond to the root zones of vegetation and are 10 to 1000 times more permeable than underlying vadose zones. Because of this large difference in permeability, many precipitation events produce a transient perched water table in a stormflow zone, and water is then transmitted downslope, above the water table, toward nearby streams. A stormflow zone thus can transmit water beneath clay caps and into waste trenches and can constitute a subsurface flow path for leaks and spills of pollutants at the surface.

Monitoring tubes consisting of 1.9-cm plastic pipe, sealed at the bottom and slotted from land surface to depths of 79 cm, have been installed at 17 locations in the headwaters area of Melton Branch. All tubes have some water inflows, indicating saturated soils and downslope flows of water. Tubes on steep slopes and in gullies generally have water inflows during small precipitation events, whereas larger or more intense events are required to produce inflows on smooth and shallow slopes.

During periods of intense precipitation, overland runoff was observed near some monitoring tubes in gullies and swales, but overland runoff apparently occurs only after the stormflow zone fills to overflowing. The overflow creates wet-weather springs; the resulting surface erosion may explain the gullies. All water samples obtained from the monitoring tubes were cloudy to muddy, and the suspended sediment was mostly colloidal. Both dissolved and sorbed chemical constituents can be transported to streams in the stormflow zone.

Comparisons of streamflow hydrographs and water level hydrographs from the stormflow monitoring tubes show that Melton Branch consists, successively, of overland runoff, stormflow discharge, and groundwater discharge during the nongrowing season. During the growing season, however, the water table drops below the level of the stream channels because of water consumption by evapotranspiration, even though lateral flows of water in the stormflow zone and the groundwater zone continue. The effects of these water fluxes on contaminant concentrations in riparian areas needs further investigation.

In partly developed to urbanized areas, the continuity of the stormflow zone is disrupted by impermeable areas, vertical barriers, drainage ditches, sumps, stormdrain systems, and permeable fill materials, including trench and pit fills. In other parts of these areas, overland runoff and water leakage from pipes, ponds, and drains may recharge the stormflow zone as well as the groundwater zone. Finally, some urban features, such as gravel pads and permeable trench-fill materials, serve as water reservoirs. The hydrogeology of such areas is complex, but remnants of the stormflow zone and networks of other features may link water sources and water discharge locations and may thus serve as flow paths for water and contaminant transport.

9.2.4 Well Surveys with the Electromagnetic Borehole Flowmeter

Below the water table on the ORR, relatively permeable fractures occur within relatively impermeable rocks. However, the depth and vertical extent of water-producing fractures cannot easily be determined with conventional procedures. An electromagnetic borehole flowmeter, newly invented by TVA, measures the vertical flow of water within a screened or openhole interval while water is pumped from, or injected into, the well. Changes in flow between one depth and another indicate the presence of a permeable fracture in this interval.

Excellent results were obtained from surveys of selected piezometer wells using a prototype instrument. Piezometer well 703, for example, is screened at depths of 18 to 24 m, but the flowmeter survey showed that the only water-producing fractures occur at depths of 23.2 to 23.8 m (Fig. 9.11, top), Also, for example, construction data for well 575 indicate a well screen at 3.0 to 4.6 m below land surface. The borehole flowmeter survey, however, showed that the well screen is at depths of 1.8 to 3.4 m and that the only permeable fractures occur at depths of 1.8 to 2.4 m (Fig. 9.11, middle), Most surveys showed that water-producing fractures have a vertical extent of 0.5 to 1.0 m. An exception is well 705, where the fractures intercept a 2.4-m length of the screen and are nearly equally permeable across the interval (Fig. 9.11, bottom).

Satisfactory results were obtained in open boreholes and in screened and sandpacked wells with water injection rates as small as 0.15 L/min. An improved instrument, developed by the TVA Engineering Laboratory at Norris, produces accurate readings for flow rates as small as 0.03 L/min. Data from this instrument can be used for (1) selecting openhole and screened intervals in future wells; (2) determining the vertical extent and relative permeability of the fractures in existing wells; (3) correcting any erroneous well-construction data; (4) calculating hydraulic conductivity values for both the fractures and the rock mass; and (5) calculating separate transmissivity values where the open interval includes more than one water-producing zone. This information should aid a better understanding of fracture hydraulics, groundwater flow paths, and contaminant transport.

9.3 K-25 SITE

9.3.1 Mitchell Branch Fish Kill

A fish kill occurred in Mitchell Branch, a zero-flow stream that runs along the northern boundary of the K-25 Site, on November 4, 1990. The cause of the fish kill was determined to be a discharge of chlorinated water from the K-1037 Building. This discharge occurred as a result of a backup cooling system that was activated when a control valve failed. Because the control valve and backup system were not equipped with alarms and no control measures were in place to prevent automatic activation of the chlorinated water backup cooling system, the discharge continued undetected for approximately 12 h at a rate of 350 gal/min (1325 L/min). The uncontrolled release resulted in a fish kill that involved more than 500 fish and effectively eliminated the fish population in the lower reaches of Mitchell Branch.

As a result of the incident, the valve for the backup cooling system in the K-1037 Building was closed. Operating procedures were revised, requiring that the valve remain closed except during supervised, controlled experiments. An evaluation of the replacement of sanitary water with unchlorinated recirculating cooling water was conducted, and all discharges from the building were evaluated. As a result, the majority of chlorinated discharges from the building to the storm drain system were eliminated.

Chlorine levels in all storm drain outfalls discharging to Mitchell Branch were also evaluated during the investigation, and five storm drains discharging potentially toxic levels of chlorine were identified. An engineering project that is scheduled for completion in March 1992 will reroute other chlorinated discharges from the Mitchell Branch storm drain system and will also place some once-through cooling systems that discharge sanitary water on the unchlorinated recirculating cooling system. A plan to install dechlorination units at the outfalls in the interim before completion of the engineering project to allow the repopulation of fish in Mitchell Branch was formulated. The units are scheduled for installation in the second quarter of 1991.

9.3.2 Upgrade of the Software Program for the Discharge Monitoring Report

A feasibility study was conducted to evaluate the alternatives for upgrading the software program used to evaluate the NPDES data and to generate the monthly DMR transmitted to TDC and EPA. Seven alternatives were evaluated, including several vendor-supplied systems, custom-developed systems, upgrading of the existing system, and systems in use at other Energy Systems/DOE facilities.

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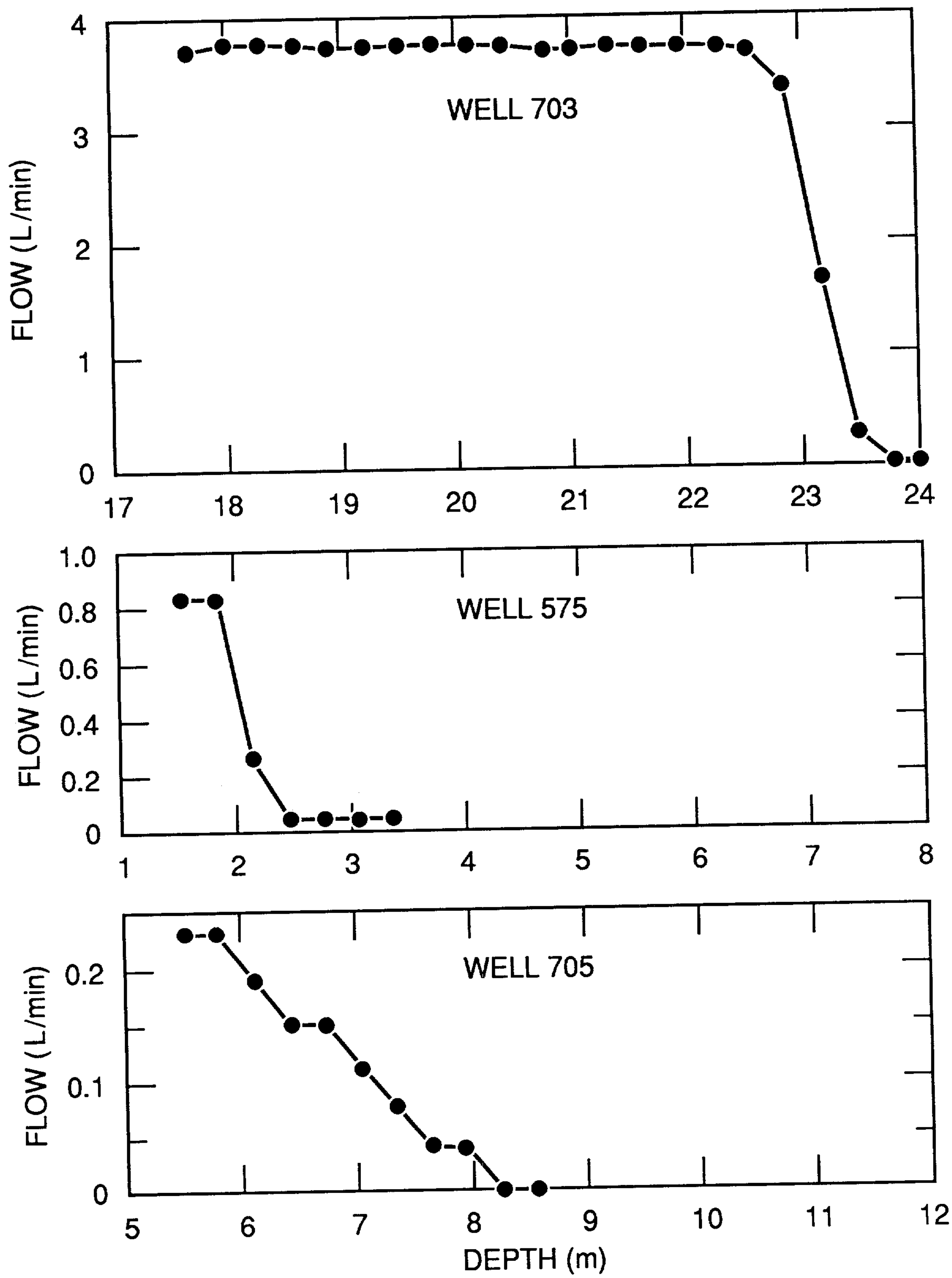

Fig. 9.11. Piezometer well surveys with an electromagnetic borehole flowmeter indicate permeable fractures at depths where changes occur in the rates of vertical flow.

The criteria used to evaluate the alternatives included the ability to provide appropriate quality control, data validation, and auditability capabilities; appropriate technical capability to produce accurate reports; capability to produce reports in a time-efficient manner to meet regulatory deadlines; cost-effectiveness; capability to electronically transmit data to regulatory agencies; reliability; maintainability; and security. Three systems were identified that satisfactorily met the criteria, and the final decision was made to adopt the system used at ORNL to produce DMRs for that facility. In addition to meeting the criteria of the feasibility study, use of the ORNL system would have the added benefit of adding an element of consistency and conformity among the Oak Ridge/Energy Systems DOE facilities in data reporting.

9.3.3 K-1407-E/F and K-1407-J Wastewater Toxicity Tests

In accordance with Part IV of the 1986 NPDES permit modification issued to the K-25 Site, the plant was required to develop and implement a TCMP. Under the TCMP wastewater from the K-1407-E and K-1407-F ponds and K-1407-J basins were evaluated for toxicity. The K-1407-E and K-1407-F ponds are discussed as one discharge (K-1407-E/F) because they are filled and discharged alternately.

The results of the toxicity tests of wastewaters from K-1407-E/F and K-1407-J are given in Table 9.1. This table provides, for each wastewater, the month the test was conducted and the wastewater's no-observed-effect concentration (NOEC) for fathead minnows and *Ceriodaphnia*. Average water quality measurements obtained during each toxicity test are shown in Table 9.2.

Wastewater from the K-1407-E/F ponds was tested six times during the year. The NOEC for the fathead minnows was always 100%. The NOEC for the *Ceriodaphnia* ranged from 6% to 100%. Because the IWC of this wastewater may be 100% during dry periods, the results of the toxicity tests show that the wastewater may adversely affect the aquatic biota in Mitchell Branch.

Wastewater from the K-1407-J basin was tested six times during the year. The NOEC for the fathead minnows and *Ceriodaphnia* was less than 100% once. Beginning in September 1989, this wastewater was discharged to Poplar Creek where it has an IWC of approximately 1%. Therefore, it is unlikely that this wastewater will adversely affect the aquatic biota in Poplar Creek.

Table 9.1. 1990 toxicity test results of the K-25 Site wastewaters

K-25 Site outfall	Test date	Fathead minnow NOEC[a] (%)	*Ceriodaphnia* NOEC[a] (%)
K-1407-E/F	Feb.	100	25
	Apr.	100	6
	June	100	6
	Aug.	100	100
	Oct.	100	6
	Dec.	100	50
K-1407-J	Feb.	100	1
	Apr.	50	100
	June	100	100
	Aug.	100	100
	Oct.	100	100
	Dec.	100	100

[a]No-observed-effect concentration.

Table 9.2. 1990 average water quality parameters measured during toxicity tests of the K-25 Site wastewaters

Values are averages of full-strength wastewater for each test (n = 7)

K-25 Site outfall	Test date	pH (standard units)	Conductivity (μS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
K-1407-E/F	Feb.	8.3	2210	76	434
	Apr.	8.4	2265	59	741
	June	8.4	3695	37	814
	Aug.	7.8	2507	41	590
	Oct.	7.9	2811	46	741
	Dec.	8.1	849	62	311
K-1407-J	Feb.	7.8	1285	94	418
	Apr.	8.1	676	177	262
	June	8.7	1926	461	197
	Aug.	8.5	952	151	244
	Oct.	8.3	1441	113	280
	Dec.	8.1	800	54	221

9.4 BIOLOGICAL MONITORING AND ABATEMENT PROGRAM (BMAP)

9.4.1 Bioaccumulation Studies

Biological Monitoring and Abatement programs (BMAPs) mandated by NPDES permits at the Y-12 Plant, ORNL, and the K-25 Site each contain tasks concerned with monitoring the accumulation of contaminants in the biota of receiving waters. The primary objectives of these studies are (1) to identify substances that accumulate to undesirable levels in biota as a result of discharges from DOE facilities, (2) to determine the significance of those discharges relative to other sources in determining contaminant concentrations in biota in receiving waters, and (3) to provide a baseline measure of biotic contamination to use in evaluating the effectiveness of any future remedial measures.

Elevated concentrations (relative to local reference sites) of mercury and PCBs in biota are associated with NPDES-regulated discharges at all three facilities. Concentrations of these substances in redbreast sunfish (*Lepomis auritus*) have been monitored twice yearly at five sites in EFPC downstream from the Y-12 Plant (Fig. 9.12) since 1985. A clear trend of decreasing mercury concentrations in sunfish with increasing distance below the New Hope Pond/Lake Reality discharge is apparent (Fig. 9.13). The mean concentrations of mercury in fish at specific sites have not exhibited an increasing or decreasing trend relative to concentrations observed in the mid-1980s, except at EFK 23.4, the site nearest Y-12. The lower mercury concentrations observed in redbreast sunfish at EFK 23.4 in 1990 are encouraging, but cannot yet be assumed to indicate a long-term trend or successful remediation of mercury bioaccumulation. A similar pattern of decreasing concentrations with distance downstream is apparent for PCBs in redbreast sunfish (Fig. 9.14). PCB concentrations in EFPC sunfish appear to have returned to levels typical of 1985–early 1986 following an increase over the 1986-1987 period.

Bluegill sunfish *(Lepomis macrochirus)* collected in fall 1989 were again found to indicate the presence of multiple sources of PCB and mercury contamination (Figs. 9.15 and 9.16). Elevated concentrations of mercury were clearly evident in fish from EFPC, Poplar Creek, Bear Creek, Mitchell Branch, and WOC. Fish from the Clinch River below the mouth of Poplar Creek contained higher concentrations than were observed in 1987 and 1988, but mean concentrations at other sites were similar to those observed previously. The mean concentration of mercury was highest at EFK 23.4 below the outfall of

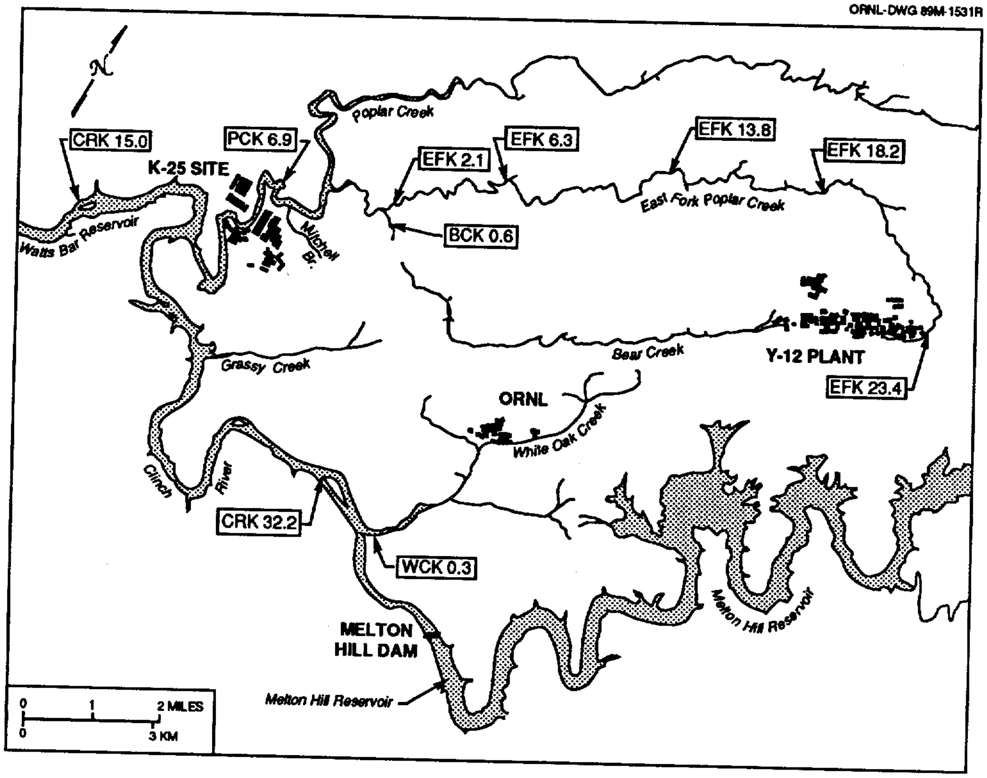

Fig. 9.12. Locations of channel catfish and redbreast sunfish collection sites for BMAP bioaccumulation studies.

Lake Reality but did not exceed the FDA limit (1 µg/g) at any site.

The pattern of PCB contamination observed in this study resembles that of mercury (Fig. 9.16). The highest mean concentrations were found in Mitchell Branch at the K-25 Site and White Oak Creek at ORNL. PCBs were elevated in fish from WOC, EFPC, lower Poplar Creek, Melton Branch, Mitchell Branch, and Bear Creek.

Sunfish serve as good indicators of PCB contamination, particularly in small streams close to specific sources, but they do not accumulate PCBs to the extent that longer-lived, larger, fattier fish such as catfish and carp do. Channel catfish (*Ictalurus punctatus*) have been found to contain PCBs approaching the FDA limit (2 µg/g) in several reservoirs in East Tennessee, including Watts Bar Reservoir (TVA 1985). As a result of finding that PCB concentrations exceeded the FDA limit in all channel catfish collected in WOC embayment in 1984 by the Oak Ridge Task Force, annual PCB monitoring in this species was initiated in 1986. Routine collection sites are depicted in Fig. 9.12; sites were selected to provide the ability to distinguish the relative importance of PCB sources in the WOC and Poplar Creek drainages in contributing to PCB concentrations in Clinch River catfish.

Quality assurance samples run in conjunction with the 1990 catfish PCB analyses suggest that the 1990 results were systematically low. If the results are multiplied by 1.5 to compensate for the low recovery of PCBs in QA samples, the results are comparable to those observed in previous years at all sites. The highest PCB concentrations once again occurred in catfish from White Oak Creek embayment. Fish from Melton Hill Reservoir, upstream from DOE-related inputs, also contained elevated concentrations of PCBs. However, additional QA investigation and possible reanalysis of some or all samples is required prior to tabulating and publishing of these results.

Chlordane contamination was again observed in clams placed in cages in WOC in 1990. As was also the case in previous years, chlordane was not elevated in fish collected from WOC. The concentrations in clams were slightly lower than those observed in 1989 and were highest near the apparent source between the 6000 and 7000 areas at ORNL.

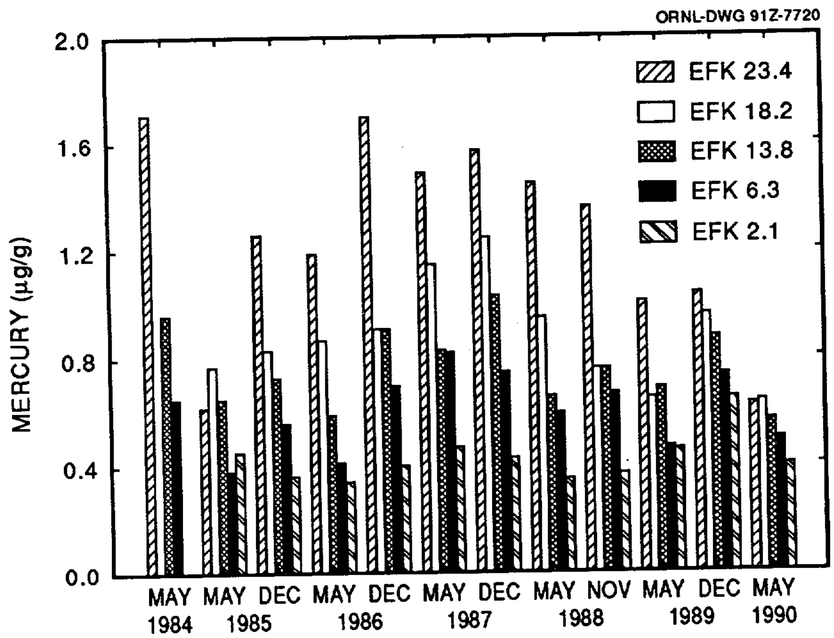

Fig. 9.13. Average concentrations of mercury in redbreast sunfish (n = 8) collected at sites in East Fork Poplar Creek, 1984–1990. The 1984 data are from the Oak Ridge Task Force study (TVA 1985). *Source:* Tennessee Valley Authority, *Instream Contaminant Study, Task 4: Fish Sampling and Analysis*, Report to DOE, Oak Ridge Operations Office, Tennessee Valley Authority, Office of National Resources and Economic Development, Knoxville, Tenn., 1985.

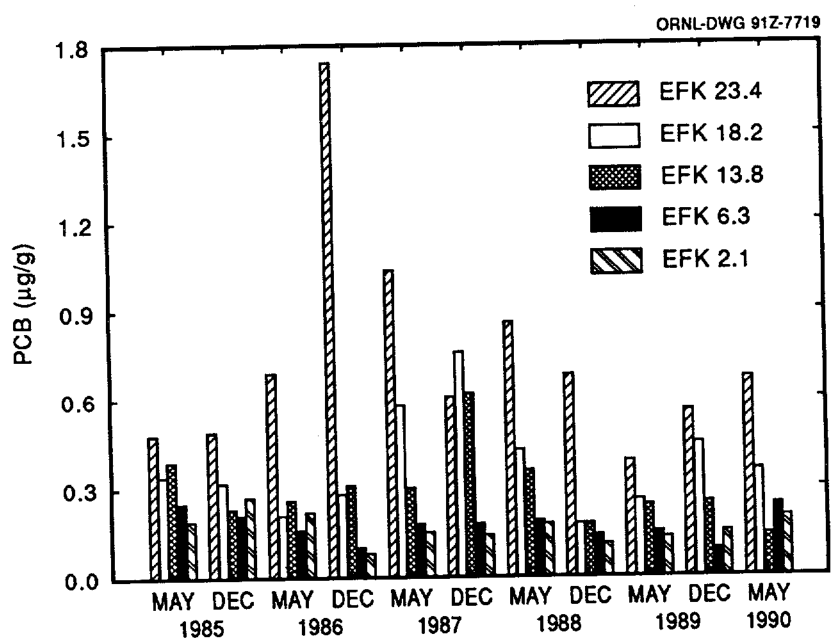

Fig. 9.14. Average concentrations of PCBs in redbreast sunfish (n = 8) collected semiannually at sites in East Fork Poplar Creek, 1985–1990.

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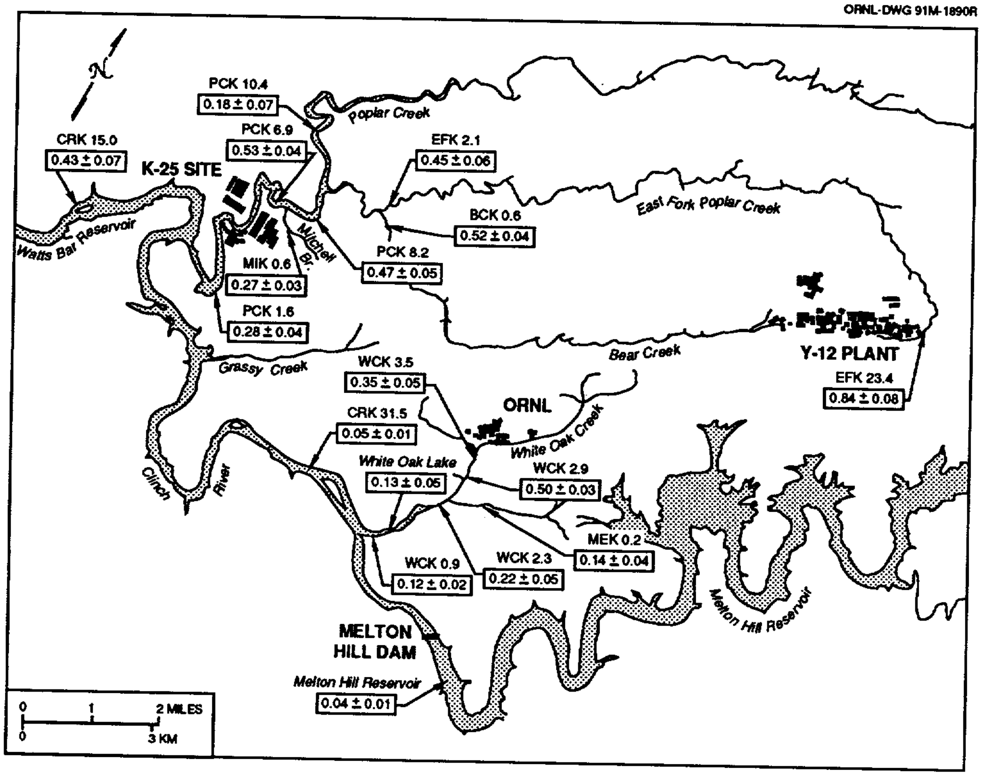

Fig. 9.15. Average concentrations (±1 SE) of mercury (μg/g, wet weight) in bluegill collected in fall 1989 at sites on the Oak Ridge Reservation. Fish at MIK 0.6 and BCK 0.6 were redbreast sunfish (*Lepomis auritus*) and rock bass (*Ambloplites rupestris*), respectively.

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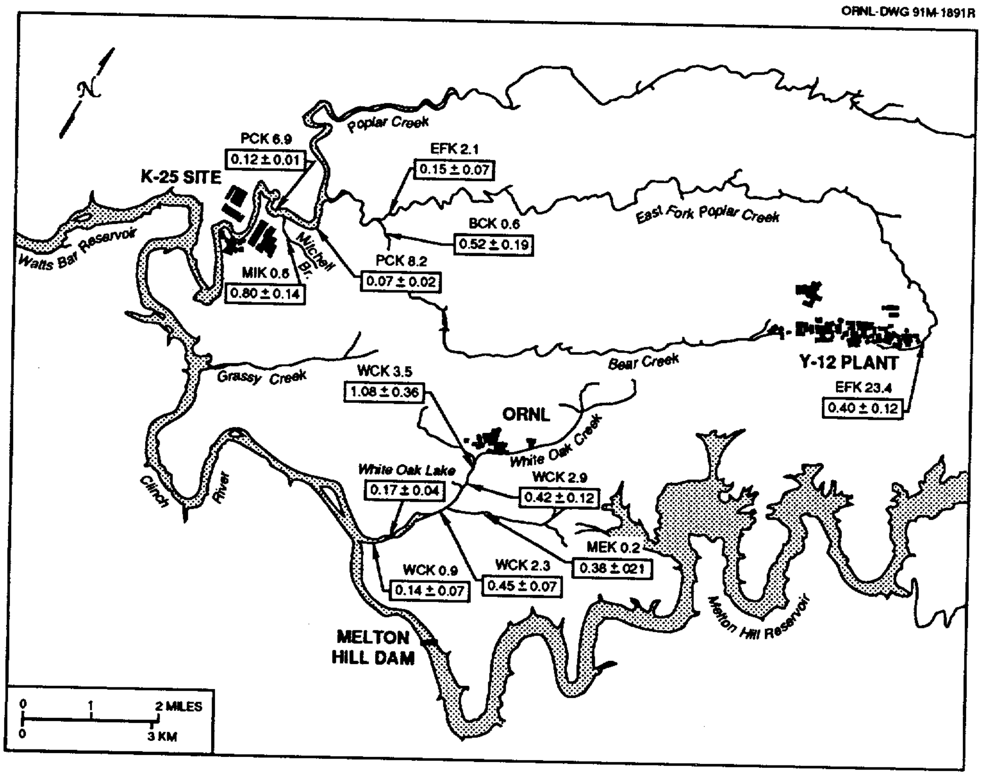

Fig. 9.16. Average concentrations (±1 SE) of PCBs (μg/g, wet weight) in bluegill collected in fall 1989 at sites on the Oak Ridge Reservation. Fish at MIK 0.6 and BCK 0.6 were redbreast sunfish (*Lepomis auritus*) and rock bass (*Ambloplites rupestris*), respectively.

9.4.2 Use of Sphaeriid Clam (*Sphaerium fabale*) Natality as an Indicator of Water Quality in East Fork Poplar Creek.

Since 1988, growth and mortality of sphaeriid clams (*Sphaerium fabale*), placed in situ, have been used as indicators of impact in EFPC below the Y-12 Plant. In these studies, clams placed nearest the Y-12 Plant (site EFK 23.4 just below Lake Reality) exhibited significant mortality and reductions in growth, while at a site about 10 km downstream (EFK 13.8), only growth was significantly reduced. The primary objective of the studies conducted in 1990 was to evaluate the feasibility of using natality of *S. fabale* as an additional indicator of water quality.

Twenty-five individually marked clams ranging in length from 9.3 to 10.9 mm were placed at each of four sites: two sites in EFPC (EFK 23.4 and EFK 13.8) and one reference site each in nearby Brushy Fork and Beaver Creek, the source stream of the clams. Each clam was placed into a small plexiglass cylinder; the cylinders were covered with 1-mm and 2-mm mesh on the upstream and downstream ends, respectively, and then securely fastened to the stream bottom. At approximately 2-week intervals during a 121-day exposure period, the contents of each cylinder were visually inspected for offspring, the lengths of the adults were measured, and mortality was noted.

At the end of the study, no clams had died at the two reference sites, but 34.8% and 17.4% of the clams at EFK 23.4 and EFK 13.8, respectively, had died. The mean length of the clams by the end of the study was at least three times greater in Brushy Fork than at the other three sites; growth in Beaver Creek and EFK 23.4 was similar, and growth at EFK 13.8 was about three times less than in Beaver Creek and EFK 23.4. Considerable differences were also evident at the end of the study in both the total offspring from all clams combined (Fig. 9.17) and mean number of offspring per individual (surviving clams only). The highest total and mean number of offspring were observed in Brushy Fork (80 and 3.8, respectively) followed by Beaver Creek (44 and 2.1), EFK 13.8 (35 and 1.6), and EFK 23.4 (22 and 1.2). Reproduction of clams at the two EFPC sites was clearly lower than at the two reference sites, thus demonstrating that natality of this species of clam may be a useful

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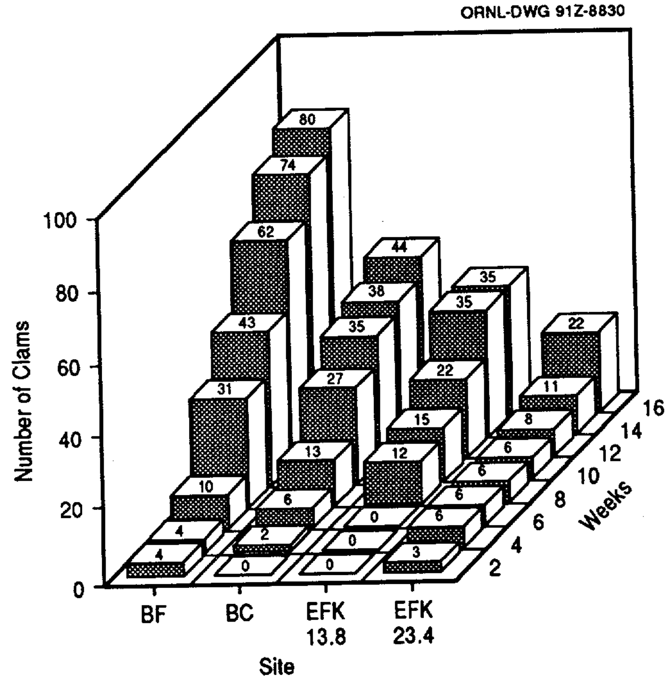

Fig. 9.17. Cumulative number of offspring of sphaeriid clams (*Spaerium fabale*) placed in East Fork Poplar Creek (EFK) and two off-site reference streams, Brushy Fork (BF) and Beaver Creek (BC). The clams were collected from Beaver Creek, placed in the various streams, and sampled at 2-week intervals over a 121-day period.

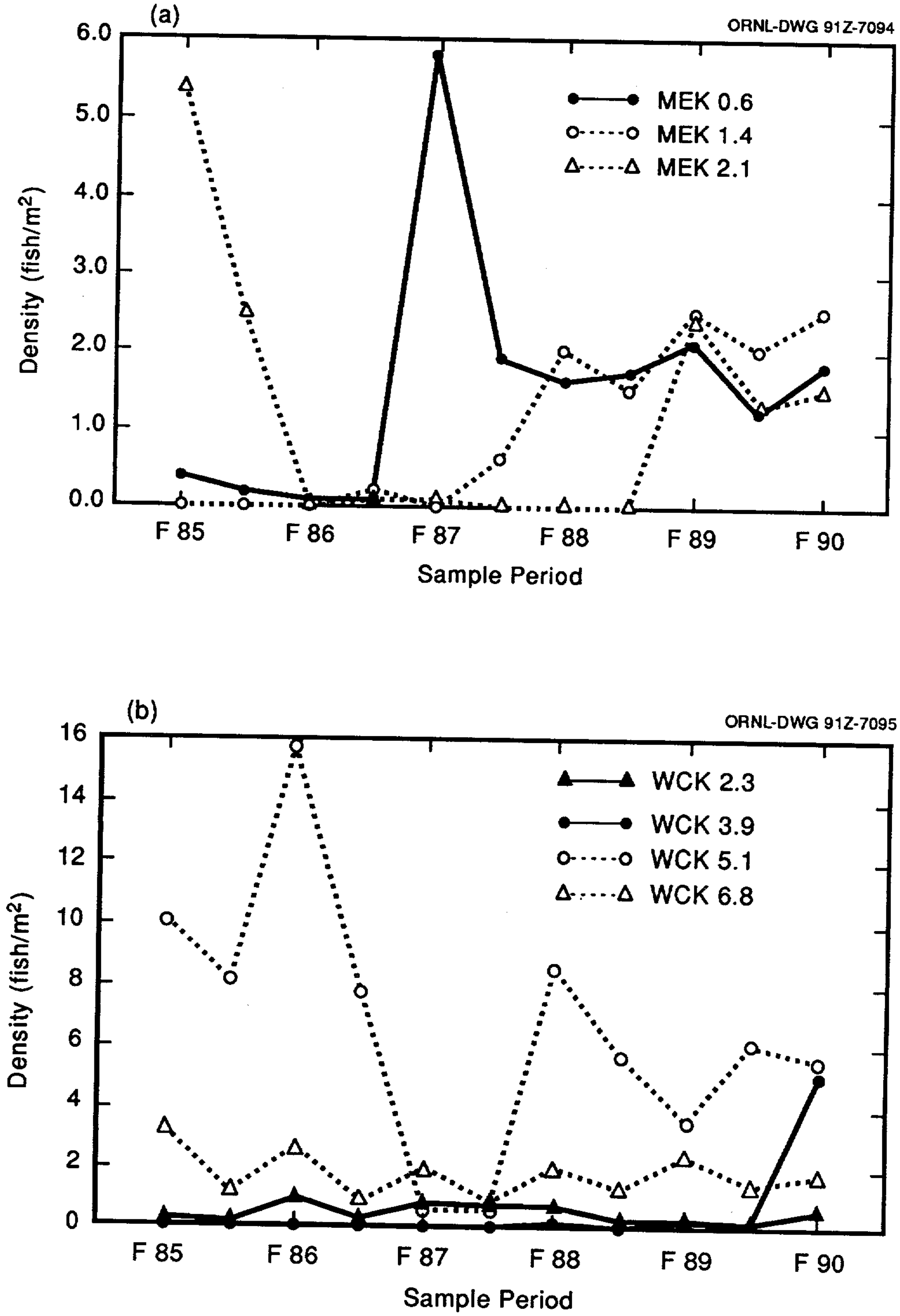

Fig. 9.18. Fish community density at three sites in Melton Branch (top) and four sites in White Oak Creek (bottom), fall 1985 to spring 1990. The upstream reference sites for the two streams are MEK 2.1 and WCK 6.8.

endpoint for monitoring the ecological health of some streams.

9.4.3 Assessment of Temporal Changes in Fish Community Abundance in Two Receiving Streams near Oak Ridge National Laboratory

The BMAPs for the three DOE Oak Ridge facilities include a task to assess the impacts of plant operations on fish communities of receiving streams. A major component of this task is the estimation of fish abundance at selected sites. Abundance (as measured by density) reflects the ecological suitability of a site for fish and can be used to identify both short- and long-term impacts on the community and the biological response of the community to changes in plant operations. Estimates of fish community abundance have been made twice yearly (spring and fall) since 1985. These data are plotted in Fig. 9.18 for three sites on Melton Branch (Fig. 9.18a) and four sites on White Oak Creek (Fig. 9.18b).

The fish communities in Melton Branch exhibited responses to both natural perturbations and ORNL operations. The upstream reference site (MEK 2.1) is a small headwater stream that is not impacted by ORNL operations but is susceptible to periods of intermittent flow. The decrease in abundance during 1986-1988 was undoubtedly related to low stream flow associated with below-normal precipitation (rainfall averaged 78% of normal during this three-year period). The recovery of the fish community in upper Melton Branch occurred in 1989 when rainfall was 120% of normal. Site MEK 1.4 is immediately downstream from the HFIR, which was shut down in November 1986. Prior to this time, fish populations at the two downstream sites (MEK 1.4 and MEK 0.6) were adversely impacted by chemical discharges and thermal loading associated with HFIR operations. When these operations ceased, successful spawning resulted in a dramatic increase in fish density at MEK 0.6, which was followed by an increase in density at MEK 1.4. The recovery of lower Melton Branch, as indicated by the change in fish community abundance, was sustained after HFIR resumed full operation in May 1990.

Unlike the headwaters of Melton Branch, upper WOC at WCK 6.8 north of Bethel Valley Road originates in the Knox Dolomite of Chestnut Ridge and is a perennial stream. Due to these flow characteristics and minimal impacts from ORNL operations, fish density exhibited little variation from 1985 to 1990 (Fig. 9.18b), reflecting population recruitment in the fall, as constrained by available food and space (i.e., habitat). Only the site farthest downstream from ORNL (WCK 2.3) showed a temporal pattern similar to that of the upstream reference site, although densities were lower. The pattern observed at WCK 5.1 between the 6000 and 7000 areas indicated a dramatic decline in abundance in 1987. Prior to that time, fish densities at this site were among the highest observed on the ORR. The decline was most likely related to the high levels of chlordane observed at this time in this reach of stream, as documented in the BMAP bioaccumulation studies. The source of the chlordane was identified as a small tributary that enters WOC just above site WCK 5.1. Finally, the very low densities at WCK 3.9 in the main plant area are most likely due to high levels of chlorine in the stream, and the recovery observed recently may be temporary and related to downstream displacement of fish by high waters. The trends in fish abundance observed in WOC and Melton Branch illustrate the value of using biological indicators to assess the effects of changes in facility operations and to promote environmental restoration and protection.

QUALITY ASSURANCE

10. QUALITY ASSURANCE

An adequate quality assurance (QA) program for environmental monitoring requires the identification, quantification, and control of all sources of error associated with each step in the monitoring program and shall ultimately lead to the prevention of errors. Factors to consider as sources of error or variance include those associated with sample collection, sample handling and preparation, analysis, data reporting, and record keeping. Thus, QA requires systematic control of all phases of the monitoring process.

Energy Systems installations participate in both internal and external quality control (QC) programs. Internally, QC is maintained through procedures and checks that include the following practices:

- use of standardized surveillance procedures;
- use of standard operating procedures (SOPs) for sample collection and analysis;
- use of chain-of-custody and sample tracking procedures to ensure traceability, defensibility, and integrity of samples and data;
- instrument calibration and verification;
- background measurements at sample source and in the laboratory;
- resolution checks and detector alignment for determination of gamma emitter radionuclides;
- yield determinations for radiochemical procedures;
- duplicate analyses for precision checks;
- use of standards to determine accuracy;
- technician and analyst training and qualification; and
- spiked and surrogate sample analysis to determine matrix effects.

Preparation of SOPs is a continually evolving process. In 1988, procedures for sampling activities were compiled, reviewed internally, and submitted to Region IV EPA for review and comment. The document, entitled "Environmental Surveillance Procedures Quality Control Program," was revised to reflect the EPA comments. EPA has approved this document for use by Energy Systems. Sample collection procedures addressing each of these areas are generally in place within each Energy Systems installation. While much work has focused on the development of sampling plans containing proper design and collection procedures, additional efforts are needed. Methods and technologies are changing rapidly, and evaluation and incorporation of these must continue.

Each installation maintains SOPs, which are reviewed and updated periodically for the collection and analysis of environmental samples. The analytical laboratories use certified standards from the EPA or DOE or materials traceable to the National Institute of Standards and Technology (NIST) to establish accuracy, calibrate instruments, determine yields for radiochemical procedures, and standardize methods.

QA and QC officers are appointed to work with the analytical laboratories to monitor the quality of analytical data. The QA/QC officers administer a program that generates QC samples of known composition, and these samples are submitted to the laboratories on an established periodic basis. These samples are prepared using EPA, NIST, or other reliable materials and are submitted as samples of unknown value to the analyst. Additionally, organizations responsible for collecting environmental samples submit blank, equipment rinse, standard, and spiked samples with environmental samples to confirm the integrity of the samples and/or to validate analytical results. These internal programs form the basis for ensuring reliable results on a day-to-day basis and facilitating the programs for training sampling technicians and laboratory analysts.

In addition to internal QC programs, analytical laboratories at Energy Systems installations participated in several external QA programs in 1990 (see Sect. 10.2).

10.1 FIELD SAMPLING AND MONITORING

10.1.1 Basic Concepts and Practices

Statistically based sampling is used because it is not possible to measure the total amount of a contaminant in the environmental media. Consequently, samples of the media are collected, and a representative contaminant concentration is estimated. An aggregate of sampling units into which an area is divided is called the population of sampling units. For example, if contaminants in pond sediments are of interest, then the population is the entire bottom sediment of the pond. If the bottom sediments are then divided into sampling units of equal size, the sampling units collectively constitute the entire population. A group of sampling units selected from the entire aggregate as representative of the whole population forms a sample (if they are composited) or a set of samples. The units forming a composite sample are typically of equal size; are taken within a defined period of time; and are selected to represent the whole population of sampling units.

Proper and cost-effective application of QA/QC cannot be accomplished without knowing the objectives of the program and the precision and confidence levels expected of the data. Once adequate sampling designs and collection procedures are in place, the quality objective is to collect the sample according to the specified procedure without altering the true nature of the sample.

Because of the changing technologies and regulatory protocols, training of field personnel is a continuing process. To ensure that qualified personnel are available for the array of sampling tasks within Energy Systems, training programs by the EPA as well as private contractors have been used to supplement internal training. Topics addressed include

- planning, preparation, and record keeping for field sampling;
- well construction and groundwater sampling;
- surface water, leachate, and sediment sampling;
- soil sampling;
- stack sampling;
- decontamination procedures; and
- health and safety considerations.

Field QC samples are collected to evaluate and validate sampling data. These control samples generally include field preservative blanks, equipment rinses, trip blanks, and duplicate samples. Tables 10.1 and 10.2 in Vol. 2 provide examples of these types of field QC samples.

10.1.2 Air Monitoring

10.1.2.1 Y-12 Plant

Air sampling methods written for the Y-12 Plant detail the preparation of sample filters and air sampling for ambient monitoring of TSP, uranium, and fluorides and procedures for continuous sampling of stack emissions. Continuous flowmeters for stack sampling are in a quarterly recall program for calibration certification by the Y-12 Maintenance Department. Meteorological tower sensors are calibrated quarterly by a subcontractor. The flowmeters for TSP samplers are calibrated quarterly by the Y-12 Plant Maintenance Department. Samplers for sulfur dioxide were checked daily by technicians, certified by Maintenance, and subjected to quarterly audits by the state until this monitoring was terminated in August 1990. Field blanks and spiked samples are routinely submitted with each set of fluoride samples.

10.1.2.2 Oak Ridge National Laboratory

ORNL has SOPs for sampling airborne emissions and ambient air. These procedures include chain-of-custody, analytical requests, recording field data, disposition of forms, collecting sampling media, and reporting system failures. Calibration of flow measuring and totalizing instrumentation is conducted every 6 months. Routine maintenance is performed annually. Calibration and maintenance of the meteorological monitoring system is performed quarterly. These procedures are controlled by the Environmental Sampling and Instrumentation Group, which is a member of the Environmental Surveillance and Protection Section in the Office of Environmental and Health Protection.

10.1.2.3 K-25 Site

The ambient air monitoring program at the K-25 Site has procedures in place for monitor maintenance, sampling, and analysis for each parameter of interest. These procedures are in the Environmental Management Department's *Operating and QA Manual*, which is reviewed and updated as determined by Environmental Management in conjunction with the Maintenance Division and Analytical Chemistry Department.

Procedures that address the requirements for emission monitoring for each operational stack at the K-25 Site are complete. All stack sampling at the K-25 Site is conducted according to EPA procedures or modifications of those procedures developed by the K-25 Site Quality and Technical Services Organization. Modifications are developed only if the original EPA procedures cannot be used for a particular application or have not been developed for a specific parameter. Such modifications are based on best available information in the field of emissions monitoring for a particular situation. The flowmeters for TSP samplers are calibrated periodically by K-25 instrument mechanics. Trip blanks and laboratory blanks are submitted with each set of air samples.

10.1.3 Water Monitoring

10.1.3.1 Y-12 Plant

Water samples are collected in accordance with EPA guidelines and protocols for appropriate containers, preservation techniques, and chain-of-custody requirements (40 CFR Pt. 136, July 1, 1987). Sampling methods are continually being upgraded to provide the best available techniques and equipment (e.g., automated samplers, flowmeters, and real-time monitoring of specific parameters in various wastewater streams).

Field blanks, field replicates, and rinse waters from equipment decontamination are routinely submitted to the laboratory to validate the reliability of a sampling technique. SOPs have been written that document the sample collection methods and ensure that appropriate techniques for installation, calibration, decontamination, and maintenance of sampling equipment are addressed. Field water quality instruments are calibrated according to manufacturer's instructions once every 4 hours of use each day and are checked weekly for general condition of membranes and filling solution as applicable. They also receive routine maintenance on a recall program every 6 months.

10.1.3.2 Oak Ridge National Laboratory

ORNL has SOPs for the collection of NPDES and other surface water samples. Chain-of-custody procedures and sample tracking are used for all NPDES and other surface water samples. Field water-quality instruments are standardized daily and calibrated every 2 weeks, or more frequently if needed. Sample containers, preservation methods, and holding times conform to 40 CFR Pt. 136 requirements.

10.1.3.3 K-25 Site

A QA/QC manual is being developed by the Environmental Management Department that will include water monitoring activities at the K-25 Site. This manual will cite procedures and activities that must exist within the plant laboratory, maintenance, and operation groups to ensure the overall quality of the program. Monitoring descriptions will be separated for NPDES and perimeter surface water and for radiological and nonradiological monitoring. Chain-of-custody procedures are used on all samples collected. Laboratory sampling and instrument maintenance and calibration procedures are used to maintain control of monitoring activities. An SPP for NPDES sampling provides for QA by requiring fill blanks, duplicate samples, and equipment blanks to validate sampling reliability.

10.1.4 Groundwater Monitoring

Sampling and analysis plans for the ORR groundwater monitoring programs adhere to EPA protocols and guidelines. Procedures for sampling methods (i.e., bailing, Bennett pumps, bladder pumps) have been written that address necessary QA concerns such as field instrument calibration, decontamination methods, and chain of custody. Field replicates, field blanks, equipment rinses, and laboratory spikes are used to validate the precision and accuracy of field and laboratory techniques.

These procedures are reviewed and accepted by TDC and EPA personnel during their respective audits of the program.

All compliance groundwater monitoring at permitted and interim status facilities is performed in compliance with the requirements set forth by EPA in 40 CFR Pt. 264/265 and Tennessee rule 1200-1-11-.05(6). Sample containers, preservatives, maximum allowable holding times, and collection methods are based on acceptable procedures as outlined by EPA.

10.1.5 Biological Monitoring

Although much literature and numerous regulatory requirements apply to the collection of certain types of samples (i.e., surface water and groundwater samples), standard protocols for the collection of most biological samples do not exist. Careful consideration must therefore be given to each type of sampling to be performed. Standard collection procedures using accepted QA/QC techniques have been developed, documented, and followed to ensure data of reproducible and known quality.

ORNL has developed SOPs for the collection of milk and fish samples at all the Oak Ridge facilities. Milk samples are collected on a monthly basis, and three composites of six to ten fish are collected at each location during each sampling period to estimate confidence limits based on statistical considerations.

A K-25 Site QA manual contains the procedures for the sampling and field chain of custody of vegetation, soil, and stream sediments in the surrounding area. These procedures are reviewed yearly and revised as needed. The QA/QC for the analysis of the biological monitoring samples is handled by the internal laboratory QA program described in Sect. 10.2.

10.1.6 Soil and Sediment Sampling

Soil/sediment sampling is another area in which considerable variability exists in the way sampling plans are designed and samples are collected. The type of soil/sediment to be sampled, the objective of the sampling effort, the parameters of concern, and many other considerations must be taken into account before an adequate sampling plan can be developed.

10.1.6.1 Y-12 Plant

As noted in Sect. 10.1.1, samples must be taken that are representative of the entire area and which address the regulatory and scientific objectives of the plan. Hence, the Y-12 Plant adheres to the fundamental statistical sampling concepts outlined by EPA (1986b). A statistician reviews the sampling approach to verify that the resulting data will meet the intended objective. For RCRA closure activities, detailed S&A plans have been developed. Field blanks, field replicates, and equipment rinses are routinely submitted to the laboratory; additional personnel are being trained in soil and sediment sampling techniques.

To ensure proper documentation of field activities in support of impending RFI studies at the Y-12 Plant, current sampling methods have been documented by the Energy Systems Environmental Surveillance Procedures Quality Control Program and approved for use by EPA Region IV. In addition, an RFI-specific Quality Assurance Project Plan has been prepared. EPA's comments on this plan are pending.

10.1.6.2 Oak Ridge National Laboratory

EPA provides guidance in the collection of soil samples for potential hazard evaluation and presents QA considerations that apply to soil sampling. ORNL uses these documents and many others when developing sampling plans and procedures for the collection of soil and sediment samples. SOPs are used for routine soil sampling such as collection of soils around the ORNL perimeter air monitoring stations.

10.1.6.3 K-25 Site

The K-25 Site has a QA manual that contains the procedures for the sampling and field chain of custody for soil around the facility. These procedures are reviewed yearly and revised as needed. QA and QC for the analysis of the soil samples are handled by the K-25 Site analytical laboratory QA program described in Sect. 10.2.

10.1.7 Solid Waste Monitoring

Each Oak Ridge installation uses SOPs and EPA manual methods for the collection of solid waste samples. These procedures incorporate unified, up-to-date information on sampling and analysis related to compliance with RCRA regulations; detailed sampling and testing methodology approved by the EPA Office of Solid Waste for use in implementing the RCRA regulatory program; and guidance in the development of collection, custody, and documentation procedures.

10.2 ANALYTICAL QUALITY ASSURANCE

The Energy Systems analytical laboratories have well-established QA/QC programs, and the highly trained and well-qualified staffs are provided with excellent equipment and facilities. Current, approved analytical methodologies employing good laboratory and measurement practices are used routinely to ensure analytical reliability. The laboratories have always been involved in the handling and analysis of hazardous materials of high purity, for which strict accountability is required. The analytical laboratories conduct extensive internal QC programs, participate in several external QC programs, and use statistics to evaluate performance. QA and QC are thus a daily responsibility of all employees.

10.2.1 Internal Quality Control

QC is a key feature in analytical QA. Analytical activities are supported by the use of standard materials or reference materials (e.g., materials of known composition that are used in the calibration of instruments, methods standardization, spike additions for recovery tests, and other practices). Certified standards from NIST, EPA, or other DOE laboratories are used for such work. The laboratories operate under specific criteria for QA/QC activities documented at each installation. Additionally, separate QA/QC documents relating to the analysis of environmental samples associated with regulatory requirements are consulted (see Tables 10.3 through 10.7 in Vol. 2).

State-of-the-art computer systems and programs, such as the "AnaLIS" program developed by employees in the K-25 Site laboratory, are used to report and track data and manage QC activities. This system provides for the recording of internal control data on known standards and the calculation of spike recoveries while ensuring that personnel have been certified before performing an analysis.

Analyses are performed using EPA, American Society for Testing and Materials (ASTM), Standard Methods for the Examination of Water and Wastewater, or other approved procedures. Analysis methods and minimum QA requirements are dictated by state and EPA regulatory requirements, DOE orders, and established laboratory QA programs.

Radionuclide monitoring, an important responsibility for the Oak Ridge plants, is supported by analytical measurements generally derived from state-of-the-art methods and instrumentation. High-purity germanium and lithium-drifted germanium detectors with standard counting configurations are used for identification of gamma-emitting radionuclides in environmental samples. Alpha-emitting radionuclides are identified with surface barrier alpha detectors, and gross alpha and beta activities are measured with proportional counting systems.

Quality control is ensured by using standard materials from NIST or other reliable sources for calibration, yield/efficiency determinations, spike recoveries, isotopic dilution, and other techniques. Backgrounds are measured periodically for corrections, and instrument responses and efficiencies are routinely established.

Nonradiological and classical wet chemical analysis methods are used to analyze environmental samples. Routine calibration and standardization, replicate analyses, spike additions, and analysis of blanks all support the internal QC efforts.

These internal programs are the mainstay of analytical QC and are the basis for ensuring reliable results on a day-to-day and batch-to-batch basis. The total effort in these programs is at least 10 to 20% of the laboratory effort (in accordance with EPA expectations).

QA/QC measurement control programs external to the sample analysis groups have single, blind control samples submitted to the analytical laboratories to monitor performance. Reliable suppliers such as NIST, EPA, and DOE are the sources for these standards. The results of such periodic measurement programs are statistically evaluated and reported to the laboratories and their customers. Most reports are issued quarterly, and some laboratories compile annual summary reports. These reports assist in evaluating the adequacy of analytical support programs and procedures. If serious deviations are noted by the QC groups, the operating laboratories are promptly notified so that corrective actions can be initiated, and problems can be resolved. QC data are stored in an easily retrievable manner so that they can be related to the analytical results that they support.

10.2.2 External Quality Control

In addition to the internal programs, all Energy Systems installations are directed by DOE and by EPA regulators to participate in external QC programs. These programs generate data that are readily recognizable as objective packets of results. These packets give participating laboratories and government agencies a periodic view of performance. The sources of these programs are laboratories in the EPA, DOE, and commercial sector.

Currently, three national programs for certification/qualification exist for analytical laboratories: the Contract Laboratory Program (CLP) for Superfund work, the Drinking Water Supply Program, and the National Institute for Occupational Safety and Health (NIOSH) Program for Industrial Hygiene Analyses. Each of the ORO installation laboratories participates in one or more of these programs. The K-25 Site laboratory participates in all three. Additionally, the ORO installation laboratories all participate in the annual EPA Discharge Monitoring Report QA Study.

Results from the Y-12 laboratory participation in the NIOSH program are listed in Table 10.42 of Vol. 2. Of the 112 measurements for 1990, 109 were acceptable and 3 were unacceptable.

10.2.2.1 Radiological Quality Control

Energy Systems laboratories participated in several external radiological QC programs in 1990. Each installation has provided results from its participation in these programs.

EPA Intercomparison Radionuclide Control Program

The EPA Intercomparison Radionuclide Control Program is administered by the EPA Environmental Monitoring System Laboratory at Las Vegas (EMSL-LV). The state of Tennessee requires participation in this control program for drinking water laboratory certification of radionuclide analysis. These samples consist mainly of water and air filters. Results are furnished to the state of Tennessee for evaluation relating to drinking water laboratory certification. Failure to obtain an overall satisfactory rating can lead to the removal of a laboratory from the certified status.

Results for each of the laboratories participating in this program are shown in Tables 10.8 through 10.10 of Vol. 2. The EMSL program calculates a normalized standard deviation for each laboratory based on all reported results. Based on their criteria, any reported value above three deviations is considered unacceptable. The Y-12 laboratory had 26 results rated as acceptable and 3 results rated as unacceptable. The ORNL laboratory had 56 results rated as acceptable, and one unacceptable. Based on ORNL's performance in this program in 1989, the state of Tennessee granted certification to the Environmental Radiochemical Analysis Laboratory through September 12, 1992. Five results for the K-25 Site were determined to be unacceptable.

DOE Environmental Measurements Laboratory (EML) Radionuclide Quality Assessment Program

A Radionuclide Quality Assessment Program is administered by DOE's EML in New York. Various matrix samples, such as soil, water, air filters, and vegetation, are submitted semiannually for an analysis of a variety of radioactive isotopes, with a statistical report submitted by EML for each period. Results for each of the laboratories participating in the program in 1990 are shown in Tables 10.11 through 10.15 of Vol. 2. All matrices, except filters, are actual materials obtained from the environment at a DOE facility. Results for each of the laboratories generally compared well with the accepted values.

The detection limits and precision depend on the counting equipment at each lab. These samples are usually near the detection limits; thus, results with ratio values of 0.5 to 1.5 as compared with reference values are acceptable data.

The parameters measured vary among laboratories because of the equipment at each laboratory. K-25 Site tests for all parameters that the existing radionuclide equipment can detect.

The Y-12 Radiochemical Laboratory participated in the May 1990 program. All nine results were acceptable. Y-12 did not participate in the September program. ORNL had two unacceptable results, one in March and one in September. All other results were acceptable.

10.2.2.2 Nonradioactive Quality Control

DOE-ORO installation laboratories participated in several external nonradiological QC programs in

1990. Each installation has provided results from its participation in these programs.

Proficiency Environmental Testing (PET) Program

In 1990, all Energy Systems analytical laboratories participated in the PET Program. Control samples were supplied by Analytical Products Group, Inc., a commercial supplier. Energy Systems analytical laboratories and WMCO at Fernald, Ohio, analyzed samples at two concentration levels (a high and a low concentration denoted as level 1 and level 2) on a monthly basis. All data were reported to the supplier from each of the six laboratories. The commercial supplier provided a report of the evaluated data, which included a percent recovery of the referenced value, deviation from the mean of all reported data, and other statistical information. Investigators at each laboratory analyzed only those parameters required on the installations' NPDES permit or parameters analyzed on a routine basis.

The vendor for the PET control program also provides a "corporate" (i.e., six-laboratory) report that compares the data from laboratories within the corporation with those of other corporate laboratories. As part of the purchase contract, the data from the six laboratories within the DOE-ORO complex (five Energy System plants and the Feed Materials Production Center laboratory) are evaluated, and a report is issued to each of the laboratory QA/QC managers. This management summary report shows problems encountered by specific laboratories.

The laboratories were statistically evaluated by PET to determine acceptability of analytical data. Data within 1.96 standard deviations are acceptable, data between 1.96 and 2.58 standard deviations are marginal, and data of more than 2.58 deviations are unacceptable.

Tables 10.16 through 10.23 of Vol. 2 show results for each of the three Oak Ridge laboratories. Data for two unknown concentrations (QC samples) or levels are reported.

EPA Discharge Monitoring Report Quality Assurance Study

EPA conducts a national QA program in support of the NPDES program. All holders of major NPDES permits are required to participate. EPA furnishes the QC samples and evaluates the results. The state of Tennessee receives the results from the Energy Systems Oak Ridge laboratories participating in this study for evaluation, and the Oak Ridge installations are required to inform the state of Tennessee of any necessary corrective actions.

Tables 10.24 through 10.26 of Vol. 2 show the results for Y-12, ORNL, and K-25. Of the 29 measurements by the Y-12 laboratory, the cadmium and lead results were unacceptable. These were the result of an error in the internal standard used in the analysis. The problem has been corrected. All results for ORNL were acceptable with the exception of cadmium, which exceeded the warning range by 0.3%. All results for K-25 were acceptable with exception of arsenic, which was a possible dilution error, and the total residual chlorine, which was a calculation error.

Water Supply Laboratory Performance Quality Control Program

The Y-12 Plant and the K-25 Site laboratories are certified by the state of Tennessee for drinking water analysis. To maintain its certification, a laboratory must meet a specified set of criteria relating to technical personnel, equipment, work areas, QA/QC, operating procedures, and successful analysis of QC samples. The state also performs an on-site audit at a set frequency. The samples are furnished by EPA-Cincinnati, and the results are evaluated by EPA-Athens (Region 4) and furnished to the state of Tennessee. To maintain the qualified status, the laboratories must satisfactorily analyze the QC samples furnished on a routine schedule.

The Y-12 laboratory performed 83 measurements. Not all were required for certification purposes. Several measurements represent two separate concentration levels for a given parameter. Seventy-nine measurements were rated as acceptable, and four were rated as unacceptable. The laboratory performs a follow-up investigation on each unacceptable result. As a result of this evaluation, the alkalinity was downgraded to provisional certification. Certification was maintained in all other areas (Table 10.27 of Vol. 2).

In 1990, ORNL and the K-25 Site participated in the multilaboratory study for the analysis of water pollution samples that is administered by EPA's EMSL-LV. ORNL analyzed four sets of samples (Tables 10.28 to 10.31 of Vol. 2) in 1990.

The K-25 Site analyzed two sets of samples in 1990. An unacceptable result was obtained for total residual chlorine because of dilution errors (Table 10.32 in Vol. 2). Unacceptable results were also obtained for Kjeldahl-N because of a possible sample mixup and for total cyanide because of a calculation error (Table 10.33 in Vol. 2). All other results were acceptable.

During 1989, the K-25 Site laboratory received results from WS-023, which was submitted in 1988. In 1990, set WP-026 was analyzed. Data for the set is shown in Table 10.34 of Vol. 2. The metals and anions that were unacceptable because of poor technique and calculation errors.

10.2.2.3 Environmental Protection Agency Contract Laboratory Program

The CLP is administered by the EPA CLP–Sample Management Office at Alexandria, Virginia, in cooperation with the EPA EMSL–LV and EPA regions. The program qualifies laboratories for the determination of organic and inorganic contaminants in aqueous and solid hazardous waste materials and enforces stringent QA protocol requirements for laboratory operation. This protocol is the only acceptable protocol for investigative, remedial, and monitoring studies of Superfund sites.

The K-25 Site laboratory has been qualified by EPA for CLP work since 1985, and ORNL began operating under the protocol in 1987. Analysis of quarterly performance samples is mandatory for certification. Results of laboratory performance are shown in Tables 10.35 through 10.38 of Vol. 2. At ORNL, the average score for the inorganic laboratories was 75.7% and the average score for the organic laboratories was 81.7%. At the K-25 Site, the inorganic data for the 3rd and 4th quarters of 1990 were returned to EPA too late for scoring. Therefore, no data for these quarters are available for Table 10.37. The average score for 2 quarters for the inorganic laboratories was 89.4% and that for the organic laboratories was 90.3%. Scores are based on a maximum 100 point system.

10.3 AUDITS, REVIEWS, AND ASSESSMENTS

10.3.1 Y-12 Plant

10.3.1.1 External regulatory

Regulatory agencies conducted several reviews at the Y-12 Plant during 1990 (Table 10.39 in Vol. 2). Reviews conducted by TDC included RCRA inspections, Compliance Evaluation Inspection (CEI) of the groundwater monitoring program, TSCA inspections, permitting inspections, and solid waste management compliance inspections. No major findings or areas of concern were identified during the inspections. Action plans have been developed to address any findings noted during the inspections.

10.3.1.2 Department of Energy

Activities are continuing to address findings identified during the DOE Headquarters Environmental Survey. The preliminary report of findings was received from DOE Headquarters in December 1987, and an action plan to address the findings was submitted to DOE-ORO in February 1988. In addition, a quarterly report is issued to DOE-ORO updating the status of on-site activities related to the survey findings.

DOE-ORO conducted an Environmental, Safety, Health, and QA appraisal of the Y-12 Plant in July 1990. In their report, the appraisal team noted 62 environmental findings. Action plans have been developed to address these findings.

The Tiger Team Compliance Assessment of the Y-12 Plant was conducted from September 25 to October 20, 1989. During the assessment, 62 environmental findings were identified. As indicated in the Tiger Team's draft report, none of the problems identified was of a nature that indicated that continued operation of the facility would present an undue risk to public health or the environment. Action plans have been developed for these findings. To date, 40 of the findings have been completed.

Some of the laboratory analytical data in the *1988 Environmental Surveillance Report* for gross alpha and gross beta activities were significantly higher than the summation of the specific radionuclide results. This was presented as a finding in the Tiger Team final report.

The normal procedure for alpha and beta activity analysis involves a preconcentration step to obtain the desired minimum detectable activity (MDA). Because of large sample loads and time constraints in reporting results to the customer at that time, in some instances the laboratory omitted this preconcentration step. Since only specific, small amounts of sample can be loaded on the counting planchet, the absence of the concentration step resulted in a higher minimum detectable activity than usual. This caused a poor correlation between the gross activities compared to the summation.

After being made aware of this inconsistency, the laboratory at that time reinstated the concentration step for all samples. The gross alpha and beta radiochemical data in the 1989 report reflects this change.

10.3.1.3 Internal

The Y-12 Plant laboratory has a program for internal audits of methods, programs, and procedures. There is an established system for audit scheduling and reporting. Audit responses are logged and corrective actions monitored.

In 1987, a subcommittee of the Five-Plant Environmental Analysis Committee was established to eliminate all the discrepancies in the systems of nomenclature that exist in our facilities. The problem has been compounded by EPA's practice of calling a compound by different names in various references—for example, tetrachloroethene and tetrachloroethylene. This has led to much confusion for lay readers of technical reports. The subcommittee continued its efforts at standardizing the names of organic and inorganic analysis parameters in CY 1988. The list of organic parameters with associated CAS numbers has been greatly expanded to cover all monitoring programs. The list of inorganic parameters has been reviewed and amended several times. Recommendations for adoption were made.

10.3.2 Oak Ridge National Laboratory

In 1990, ORNL experienced numerous audits/inspections and reviews related to environmental sampling and data management, sample analysis, waste management, and QA. These audits and reviews consisted of audits by outside regulatory agencies such as the EPA and TDC; audits and reviews by DOE Headquarters and DOE-ORO; and internal audits by Energy Systems.

10.3.2.1 External Regulatory

Table 10.40 of Vol. 2 summarizes the major environmentally related audits and reviews of ORNL by outside regulatory agencies. The major audit for the year was the DOE Headquarters Tiger Team Review conducted from October 22 to November 30. This audit resulted in 42 findings associated with internal compliance with internal procedures, corporate policies, or regulatory requirements. An additional 27 findings were associated with best management practices. Other major audits included a RCRA inspection that resulted in no findings and an EPA Region IV Compliance Evaluation Inspection that received a rating of 4 out of a possible 5.

10.3.2.2 Internal

In addition to the EPA, state of Tennessee, and DOE audits and reviews, Energy Systems and ORNL organizations external to the divisions and groups responsible for environmental concerns at ORNL performed numerous audits and reviews of the environmental program at ORNL.

These audits and reviews focused on the environmental program, recordkeeping, health and safety QA, contingency plans, and storage of toxic and hazardous waste. In many cases, these audits and reviews led to improved operating procedures and management practices.

10.3.3 K-25 Site

10.3.3.1 External Review

Table 10.41 of Vol. 2 summarizes the major environmental audits and reviews of the K-25 Site.

TDC conducted a review for Groundwater Compliance in February 1990. No findings were reported, but improvements were suggested for the Groundwater Quality Assessment Plan Outline. EPA conducted a review of the TSCA Program in February 1990. Several items concerning the storage of PCBs were identified.

In June 1990, the state reviewed the air program at the K-25 Site and stated that permit conditions needed to be documented. The NPDES program was reviewed by EPA in June, and minor deficiencies were noted in some of the sampling methods. These have been corrected.

In August, the state conducted a RCRA compliance review in August and reported several storage violations at the K-1417 Storage Yard. In December, a surveillance of TSCA readiness was conducted. One of the findings dealt with the completion of the Request for Services forms.

10.3.3.2 Department of Energy

DOE-ORO conducted an Environmental Protection Appraisal on January 16–26, 1990. Fifty-three recommendations were made in the report. Many were concerned with the documentation and implementation of procedures in the area of the development of QA Plans and SOPs in the Environmental Quality Assurance and Monitoring review. Also, inadequate training programs were identified in the Hazardous/Mixed Waste Management and Toxic and Hazardous Substance Control programs. Another area identified as needing improvement was the overall environmental coordination and management of various activities. An action plan was prepared to address the recommendations made by the appraisal team.

DOE-ORO audited the RCRA/TSCA/Waste Management programs in August 1990 for compliance with the regulations. Most of the findings dealt with quality assurance.

10.3.3.3 Internal

In addition to the EPA, TDC, and DOE audits and reviews, Energy Systems and the K-25 Site organizations perform audits and reviews of the environmental programs at the K-25 Site. These audits and reviews focus on record keeping, laboratory and sampling procedures, and storage of hazardous materials and waste. These have led to improved operating procedures and management practices.

10.4 QUALITY INCIDENTS

The Y-12 result for arsenic on the March level-1 PET sample was unacceptable. Investigation showed that the internal quality control data associated with the analysis was acceptable. No specific cause could be determined.

In July, both levels for the hardness were in the unacceptable range. Upon review of the data, an error in the calculation was discovered. The phenol level-1 sample was also in the unacceptable range. No cause could be determined.

The Y-12 level-2 fluoride result was in the unacceptable range for April. The laboratory discovered a problem with the electrode used in the procedure. The problem was corrected.

For the NPDES performance sample, the Y-12 laboratory had results for lead and cadmium listed as unacceptable. These were the result of an error in the program using the internal standard, causing results to be biased high. The problem was corrected.

For the drinking water certification program, the Y-12 laboratory failed to make a necessary calculation correction before reporting the nitrate-nitrite nitrogen results. Technicians have been reminded of the correct calculations.

APPENDIXES

Appendix A

GENERALIZED STRATIGRAPHIC AND STRUCTURAL DESCRIPTIONS OF GEOLOGIC FORMATIONS IN THE ORR

A.1 STRATIGRAPHY

Rome Formation

The Cambrian Rome Formation underlies Haw Ridge and Pine Ridge and is the basal decollement for the Copper Creek (CC) and WOM thrust faults. The Rome Formation consists of massive to thinly bedded, maroon to gray-green sandstones interbedded with greatly subordinate amounts of thinly bedded, silty mudstones; shales; and dolomite.

The upper portion of the section contains a distinctive gray to gray-green sandstone, and the lower section is much more heterogeneous (Haase et al. 1985). Locally, the Rome Formations contains a significant dolostone component, which represents coeval and interbedded deposition of Shady Dolomite and the Rome Formation. Hence at the ORR, the Shady Dolomite is a stratigraphic equivalent of and does not lie underneath the Rome Formation (McReynolds 1988). Maximum stratigraphic thickness of the Rome Formation in the ORR is about 300 ft. However, because the Rome Formation is the basal décollement for the major thrust faults in the area, apparent thickness values vary considerably because of structural duplication or removal of intervals.

A.1.1 Conasauga Group

The Cambrian Conasauga Group underlies Melton and Bear Creek valleys. In this area of eastern Tennessee, the Conasauga Group is divided into six formations of alternating shale and carbonate-rich lithologies. From oldest to youngest these are: the Pumpkin Valley Shale, the Rutledge Limestone, the Rogersville Shale, the Maryville Limestone, the Nolichucky Shale, and the Maynardville Limestone. As a whole, weathering of the Conasauga Group forms fractured saprolite as much as 12 m (40 ft) thick that is covered by a fairly thin veneer of soil. Descriptions of the units are primarily derived from Haase et al. (1985) and King and Haase (1987).

Pumpkin Valley Shale [79.2–106.6 m (260–350 ft)]

The Pumpkin Valley Shale consists of massive to thinly bedded, maroon-brown to gray mudstones and shales interbedded with thinly bedded to laminated glauconitic siltstones. Two members can be identified, with the upper one being more shale- and mudstone-rich than the lower one. The lower member contains abundant zones of mottled, bioturbated shaly siltstones interbedded with thinly bedded shales and siltstones.

Rutledge Limestone [27.4–42.6 m (90–140 ft)]

The Rutledge Limestone consists of light-gray to white, medium to thinly bedded limestones and shaley limestones interbedded with medium to dark gray, thinly bedded to laminated, calcareous mudstones and shales. A persistent 1.5- to 3.0-m (5- to 10-ft) thick interval of maroon to maroon-gray mudstone occurs toward the base of this formation and serves as a marker bed within the lower Conasauga Group throughout Bear Creek Valley.

Rogersville Shale [27.4–42.6 m (90–140 ft)]

The Rogersville Shale is composed predominately of massive to medium bedded, gray to maroon mudstones interbedded with medium to very thinly bedded, gray to maroon-brown shales. The shales and mudstones contain subordinate amounts of thinly bedded, glauconite-rich, locally calcareous siltstone. Within the middle and upper portion of the shale, a locally stromatolitic (Hasson and Haase, 1988) carbonate unit, the Craig Limestone Member, of variable thickness is observed. It consists of mottled fine-grained limestone and dolostone to coarse-grained intraclastic and oolitic limestone (Walker and Simmons 1985).

Maryville Limestone [103.6–141.1 m (340–463 ft)]

The Maryville Limestone consists of light to dark gray, fine to coarsely crystalline limestone interbedded with subordinate amounts of dark gray, medium to thinly bedded calcareous shales and shaley siltstones. The Maryville Limestone can be divided into two members (Haase and Tank 1985), with zones of limestone-pebble conglomerates and ooid-rich beds being locally abundant in the upper member. The lower member consists of medium to thinly bedded calcareous shales and siltstones with subordinate amounts of crystalline limestones. Limestone-pebble conglomerates and ooid-rich beds are rare to nonexistent in the lower member (Haase and Tank 1985).

Nolichucky Shale [128–167.6 m (420–550 ft)]

The Nolichucky Shale can be divided into three members: the Upper Shale, the Bradley Creek, and the Lower Members (Hasson and Haase 1988), although identification of these members in Bear Creek Valley is not straightforward. The formation consists of maroon-brown to rare green-gray, massive to very thinly bedded, locally calcareous mudstones and shales interstratified with thinly bedded, medium-gray limestones and calcareous siltstones. The maroon-brown color of the shales is characteristic of the Nolichucky Shale. The interbedded limestone typically contains limestone-pebble conglomerates and ooid-rich beds similar to those occurring in the underlying Maryville Limestone. Throughout much of the Nolichucky Shale, mudstone/shale and limestone lithologies alternate every of 0.3 to 0.9 m (1 to 3 ft), giving the formation a thickly bedded appearance.

Maynardville Limestone [97.5–137.1 m (320–450 ft)]

In the ORR, the Maynardville Formation shows a gradational lower contact with the Nolichucky Shale (King and Haase 1987). The Maynardville Limestone is composed of light gray to tan, massive to thinly bedded limestone with subordinate amounts of dolostone. This formation can be divided into members on the ORR (Haase et al. 1985). The uppermost Chances Branch member consists of medium- to thin-bedded buff and light-gray dolostones, ribbon-bedded dolostones/limestones, and thin-bedded medium-gray limestones. The lower Low Hollow member is principally wavy to evenly thin-bedded (oo)microsparite, with alternating horizons of dolomite-bearing, ribbon-bedded microsparite and calcarenite. The Low Hollow Member and the lower portion of the Chances Branch Member are oolitic, and soft sediment deformation fabrics have been observed (Geraghty and Miller 1987). Both members are locally stylolitic.

A.1.2 Knox Group

The Cambrian-Ordovician Knox Group underlies Copper Ridge, Chestnut Ridge, McKinney Ridge, and Blackoak Ridge. In eastern Tennessee, the Knox Group can be divided into five formations of dolomite and limestone. At the ORR, all five have been identified by field surface mapping, and unit descriptions listed in Appendix A are derived from field mapping at other locations in eastern Tennessee (Hatcher and Bridge 1973). Detailed thickness measurements of the individual units have not been made on the ORR; however, the entire group is estimated to be approximately 731 m (2400 ft) thick (Lee and Ketelle 1989). In ascending order, the formations in the Knox Group are the Cambrian Copper Ridge Dolomite, the Ordovician Chepultepec Dolomite, the Longview Dolomite, the Kingsport Formation, and the Mascot Dolomite. Identification of lithologic contacts in fresh core is not as direct, and thus discrepancies exist between field and core studies. The Knox Group weathers to a thick [up to 45 m (150 ft)], orange-red clay residuum that commonly contains abundant chert. Primary structural fabrics generally are not preserved in the residuum. Significant portions of the areas underlain by the Knox Group are characterized by karst features.

Copper Ridge Dolomite

The Copper Ridge Dolomite is a resistant ridge former. It consists of thin- to thick-bedded olive-gray, grayish-black, and yellow-brown dolomite that is microcrystalline to coarsely crystalline. Freshly broken surfaces give off fetid odor, particularly in the lower part of the formation. Beds in the lower part of formation are thinner and finer grained than in the upper part of the formation. The contact between the Copper Ridge Dolomite and the Maynardville Limestone is drawn below a thin, fine-grained quartz sandstone containing white oolitic chert. The top of the formation is above a 0.9- to 2.4-m (3- to 8-ft) dolomite matrix sandstone. This sandstone is very persistent in float.

The Copper Ridge Dolomite weathers to clay residuum containing abundant black, medium- to coarse-grained oolitic chert; black cryptozoan chert; light-colored chert in blocks as much as 0.9 m (3 ft) in diameter; and some blocks of fine- to medium-grained quartz sandstone with dolomite cement.

Chepultepec Dolomite

The Chepultepec Dolomite is less resistant and occupies relative topographic lows in ridges comprised of the Knox Group. It consists dominantly of dolomite and limestone. The dolomite is finely crystalline, light gray and pinkish brown to light brown, thick-bedded, with numerous dolomite-cemented sandstone beds and some silica-cemented sandstones. The limestone is olive gray and brownish black and weathers to light gray with silty mottling on its surfaces. It is cryptocrystalline to very fine-grained, thick-bedded, and contains quartz geodes. Sandstone beds as much as 3 m (10 ft) thick with fine to medium rounded quartz grains are common in the lower part of formation. A bed of fine-grained, white, siliceous ooids occurs 9.1 m (30 ft) above the Copper Ridge/Chepultepec contact. White oolitic chert is abundant in the formation.

The formation weathers to a dark-orange clay residuum that contains nodular, varicolored, porous, and ropy chert. Sandstone in the lower part of the formation weathers to loosely cemented cherty blocks.

Longview Dolomite

The Longview Dolomite is a resistant ridge former that consists of both dolomite and limestone. The dolomite is siliceous, light to very light gray, finely to coarsely crystalline, thin to thick bedded, with rounded quartz grains throughout the unit. The limestone is light-bluish-gray, dense to fine grained, and medium to thick bedded, and it constitutes as much as half of the upper part of the formation.

The formation weathers to a light-ash-gray clay residuum containing massive, chalcedonic porcellaneous, dead-white to light-pink, brown, and gray chert blocks 0.6 m (2 ft) to more than 1.5 m (5 ft) in diameter. The chert is jointed and easily fractured and includes sparse oolitic chert.

Kingsport Formation

The Kingsport Formation is a less resistant dolomite and limestone. The dolomite is light gray and yellowish gray and weathers to a very light gray to white color. It is fine to coarsely crystalline, thin to medium bedded, and locally laminated. The limestone is light-olive-gray and medium-gray, cryptocrystalline to crystalline, and medium to thick bedded. The formation contains beds of chert nodules about 2.54 cm (1 in.) thick, medium-rounded quartz grains, and sandstone beds 2.54 cm (1 in.) or less thick. The top of the formation is more dolomitic than the bottom, and the lower contact with the Longview Dolomite is characterized by a significant decrease in chert.

The formation weathers to a clay residuum that contains oolitic, nodular chalcedonic, varicolored, and white porous chert, and local thin, dolomite-cemented sandstone fragments.

Mascot Dolomite

The Mascot Dolomite is a resistant unit that consists of dolomite with lesser amounts of limestone. The dolomite is siliceous and locally cherty; medium gray to medium dark gray or olive gray; cryptocrystalline to fine crystalline, locally laminated, and thin to medium bedded. The limestone is olive gray and medium dark gray, cryptocrystalline, and medium to thick bedded with some silty partings, and it commonly shows a conchoidal fracture. A continuous "chert matrix" sandstone or quartz sandstone occurs at the base of the formation.

The formation weathers to a clay residuum that contains chalcedonic chert, nodular chert, porous white chert, and sandstone fragments with a dolomite matrix.

A.1.3 Chickamauga Group

The Ordovician age Chickamauga Group underlies East Fork Valley, the K-25 Site area, and Bethel Valley. These rocks comprise the footwall immediately below the major thrust faults in the ORR. The Chickamauga Section has been described from two areas within the ORR: (1) at the eastern boundary of the Reservation near Solway Bridge (Weiss 1981) (Fig. A.1 and (2) at ORNL site (Lee and Ketelle 1988). The sections are approximately 10 km (6 miles) apart and both are located on the WOM thrust sheet. In general, the Chickamauga Group consists predominantly of limestones with interlayered carbonate-rich shales. Although descriptions of the two sections use different nomenclature schemes, it is possible to derive a rough correlation between parts of the two sections, based on narrative rock descriptions and geophysical logs acquired at the ORNL site.

Lower Chickamauga Group [91.4–96 m (300–315 ft)]

In this part of East Tennessee, the lower Chickamauga Group consists of the Blackford and Lincolnshire Formations, which were deposited on the Upper Knox unconformity. These units are tentatively correlated with unit A of Stockdale (1951) and Lee and Ketelle (1988). Lithologic and thickness differences between measured sections of the Lower Chickamauga Group may be attributed in part to local relief on the Knox unconformity. The Blackford Formation consists of maroon and olive-gray dense limestone and mudstone that is partially dolomitized. The top of the formation shows thin to medium laminations. The lowest member of the Lincolnshire Formation, the Eidson, is characterized by a shaley calcareous siltstone that contains bedded or nodular black chert. The unit is commonly thin and wavy bedded with limestone partings. The Hogskin Member of the Lincolnshire Formation is poorly exposed at Solway and is presumed to be correlative to X-10 units A3–A5, which are maroon calcerous siltstones with limestone beds and chert-rich limestones.

Middle Chickamauga Group [259–314 m (850–1030 ft)]

The transition between the Lower and Middle Chickamauga Group is marked by a significant increase in shale/mudstone content (Weiss 1981). This is inferred from the weathering profile at the Solway section and observed in core and geophysical logs at X-10 (Lee and Ketelle, 1988). The lowest formation of the Middle Chickamauga Group, the Benbolt Formation, is characterized at its base by a thick shale that grades into a more resistant siltstone and limestone at the top and is provisionally correlated with X-10 units B and C. Immediately above the Benbolt, the lower Wardell Formation is comprised of a light gray, medium-grained, dense crystalline calcarenite. Bedded and nodular chert and birdseye micrite are common, and fossils occur in patches or in sharply defined beds.

Middle Chickamauga Group correlations between Solway and X-10 are not straightforward above the lowermost section of the Wardell Formation. The Middle Chickamauga/Moccasin Formation contact has been defined by the introduction of maroon argillaceous limestones above the Witten Formation and is provisionally placed at the X-10 G/H contact. Using these correlations, the remainder of the Middle Chickamauga Group (the upper Wardell, Bowen and Witten; see Fig. A.1) shows a doubled stratigraphic thickness at the X-10 site in comparison to the Solway site. In addition, rock descriptions and detailed thicknesses do not directly match between the two sites, and five 0.9- to 1.5-m (3- to 5-ft) deformation zones have been reported from these rocks at the X-10 site. The thickness discrepancies between the two sites can be caused by an abrupt stratigraphic thickening or, as suggested by the presence of local deformation zones, by structural duplication.

Moccasin Formation [67 m (220 ft)]

The Moccasin Formation is characterized by maroon, argillaceous limestone and mudstone that overlies the Witten Formation. The lower contact is marked by a color change from dark or light gray to

ORNL-DWG 91M-1634R

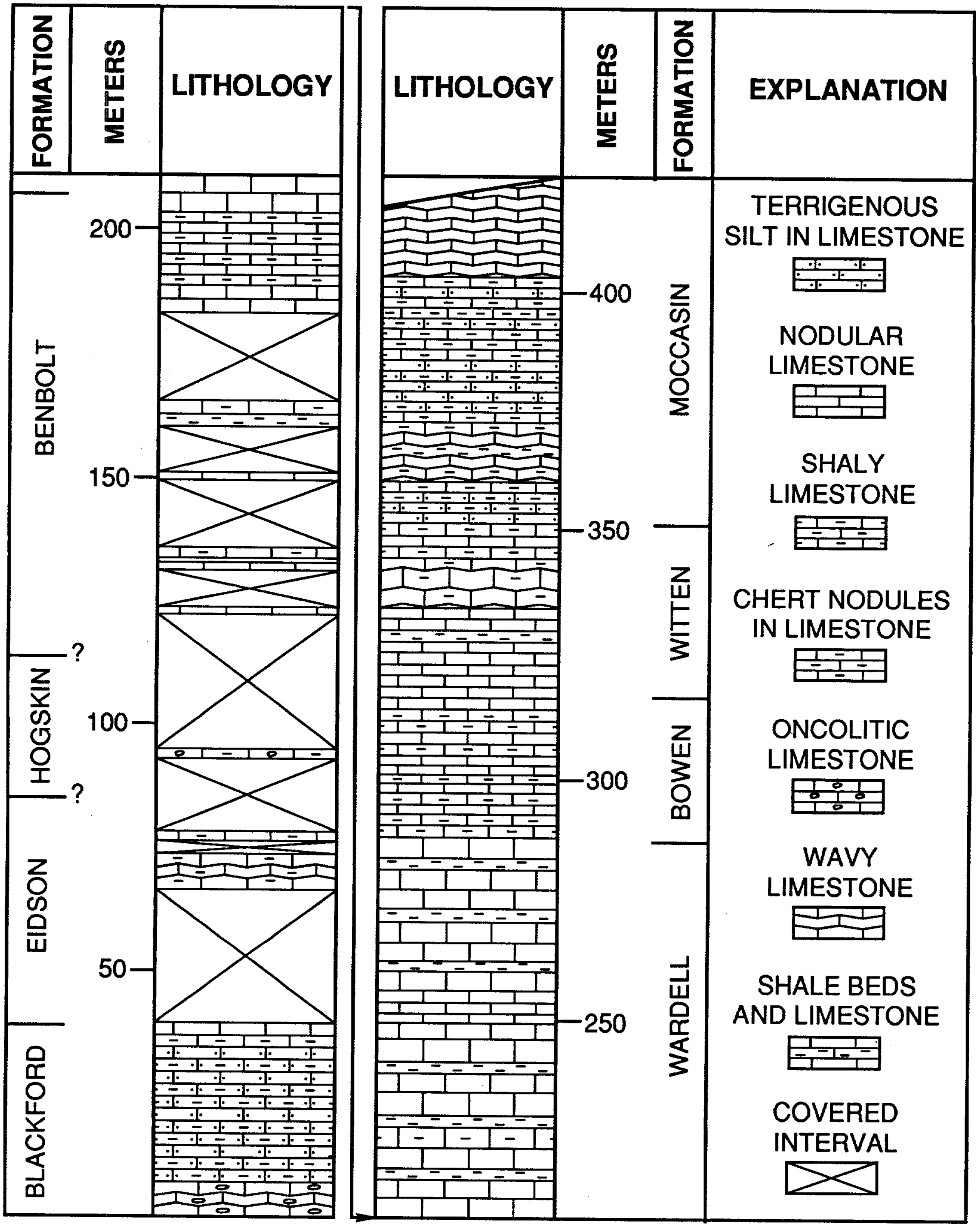

Fig. A.1. Chickamauga Group—Solway section.

a pale maroon color and a gradational change from a wavy, interbedded, nodular, and ribbon limestone to a calcareous siltstone interbedded with fine-grained limestone. True stratigraphic thicknesses of the Moccasin Formation are not exposed at the ORR because the formation is truncated by the Copper Creek Fault.

Post-Chickamauga Rocks

Units younger than the Chickamauga Group are only observed in the core of two strike parallel synclines north of the WOM Fault. These units consist of Upper Ordovician to Lower Mississipian limestones, shales, and siltstones.

A.2 STRUCTURE

Faults and Folds

Three regionally extensive thrust faults crop out on the ORR. They are the CC, WOM, and Kingston faults. All of these faults extend from the surface to the geologic basement at approximately 426 m (1400 ft) (Fig. 1.11), trend parallel to regional strike (N55E), and show displacement of at least of several kilometers. The WOM Fault dips steeply (45°) to the southeast (King and Haase 1987) and is characterized by complex deformation (Figs. 1.10 and 1.11). A sequence of cross-cutting imbricate splay faults repeatedly stack the Rome Formation in the hangingwall, and slices of the Knox Group and Chickamauga Group have been complexly stacked, rotated, and folded in the footwall to the WOM Fault. In contrast, the CC Fault in the ORR shows a shallow dip (0–25°) and displays a relatively simple outcrop pattern, although portions of the Chickamauga Group in the footwall of the CC Fault may be structurally duplicated. Locally, the CC fault zone ranges in thickness from 0–23.5–m (0–77 ft) (Haase et al. 1985; Stockdale 1951). Thickness information for the other fault zones is not available.

On a smaller scale, the thrust sheets are cut by (1) high-angle tear faults that form as a result of differential movement of the thrust sheet and (2) minor thrust faults that form as a result of thrust movement over a curved surface. The existence of the tear faults has been inferred by local offset of topographic ridges, prominent topographic depressions, stream patterns, and is indicated by discrepancies in lithologic contacts as determined from borehole data (Dreier and Leat 1988). The majority of these features show a consistent northward trend that is oblique to the regional strike. Because they are tear faults, these structures probably show minor displacement 0–100 m (0–328 ft). Nevertheless these faults should have associated fracture zones.

Thrust faults have been identified from core, geophysical logs, topographic linements, and surface folding characteristics. The most consistent zone of thrusting appears to occur in the middle to upper portions of the Maryville Limestone and in the lowermost Nolichucky Shale (Haase et al. 1985; Lee and Ketelle 1989; Dreier and Leat 1988). These horizons may be a zone(s) of inherited deformation that has been passively transported by regional thrust faults and locally reactivated by local perturbations in fault geometry. Displacement along these thrust faults has not been measured. However, geologic constraints suggest that maximum displacement does not exceed 25 m (82 ft). Nevertheless, fracture zones up to 10 m (33 ft) are associated with these features (Dreier and Leat 1988). Tight, locally overturned folds with wavelengths that range from centimeters to several meters are commonly associated with these minor faults.

Fractures

Fracturing is pervasive throughout all rock units in the ORR. Because permeability and porosity of bedrock are strongly influenced by secondary-fracture permeability and porosity, studies have recently been initiated to investigate fracture characteristics in sections of the ORR. Detailed investigations of Conasauga Group core from Bear Creek Valley show that five fracture sets occur consistently throughout the core. One set is parallel to bedding and the other four are generally perpendicular to bedding. Assuming a regional strike of N55E, the strikes of the high angle sets are approximately N55E (strike-parallel), N75W, N15E, and N20W. The bedding-parallel fractures are mainly release joints that may have formed in situ or as a result of coring. Studies elsewhere in the Appalachians suggest that release joints can form at depths up to 1 km (0.6 mile). In Melton Valley, field studies in waste management areas show a slight difference in the orientation of the high-angle fractures with respect to those measured in Bear Creek Valley. Here, there are prominent strike-parallel and strike-perpendicular sets with associated shear fractures (Dreier et al. 1987; Mares 1988).

Although the rock units are highly fractured, most fractures at depth are sealed by mineral precipitates (predominantly calcite) and do not contribute to secondary permeability. Open fractures are most common within 45 m (150 ft) of land surface and in deformed massive shale units (Dreier et al. 1988), although exceptions to this generalization do exist. Open fractures usually occur as a function of depth below land surface, lithology, and degree of deformation.

Karstification, or solution enlargement of existing fractures, is common in the more carbonate-rich units and is present in the Knox Group, the Chickamauga Group, the Maynardville Limestone, and carbonate-rich portions of the Nolichucky Shale. Cavities generally range in thickness from <30 to 91 cm (<1 to 3 ft), although cavities from 2.4 to 3.4 m (8 to 11 ft) thick exist (Rothschild 1984). The cavities commonly parallel bedding planes.

Appendix B

STATISTICAL TREATMENT OF RANDOM UNCERTAINTIES

Random uncertainties are those that can be treated by statistical methods and are derived from an analysis of replicate observations of a random or stochastic process. The information in this appendix has been taken directly from *Upgrading Environmental Radiation Data,* EPA 520/1-80-012, prepared by the Health Physics Society Committee, 1980. Only a small amount of background information is presented here.

Before proceeding, definition of some terminology is necessary. The term variate (or random variable) is used to denote the quantity that may take on any of the observed values. The aggregate of these observations is termed a sample of some parent population and may be described by a frequency distribution. This distribution of the population is a specification of the way in which the number of observations (frequencies) are distributed according to the values of the variates. The parameters of a population are the descriptive measures of the distribution. The mean (μ), a measure of the center or location of the distribution, and the standard deviation (σ), a measure of the spread or scatter of the distribution, are examples of parameters. The mean (μ) is also termed the first moment of the distribution, and the square of the standard deviation (σ^2), called the variance, is the second central moment. In the absence of an infinite population, one must make estimates of the parameters from finite populations (the sample of observations). A sample statistic is this estimator of the population parameter. The values of sample statistics are computed entirely from the sample and are the basic measures of the central tendency (location) and dispersion (variation). The mean ($\bar{x}$) and standard deviation (s) are widely known examples of statistics. Unfortunately, the distinction between population parameters and sample statistics is frequently ignored, and the two are often confused and incorrectly referred to interchangeably. The following diagram is an attempt to clarify the distinction.

Statistics	→	Parameters
Calculated from sample (e.g., $\bar{x}$ and s^2)	used to estimate	for the population (e.g., μ and σ^2)

In practice, the parameters of the population are denoted by Greek alphabetic characters, and the corresponding estimators of these parameters (the statistics) by Roman alphabetic characters. Table B.1 lists a number of commonly used parameters and statistics.

The population distribution must be known before one can proceed with the treatment of random uncertainties. A rigorous analysis would require confirmation that the sample of observations is a normal or some other known distribution. Numerous statistical tests, such as the χ^2-, t-, and F-tests, are available for this use. Standard statistical sources may be consulted for details. These tests are not always practical, particularly because they are not very applicable with samples of less than about 30 observations. With fewer observations, a normal (or Gaussian) distribution, which is completely characterized by the mean and variance, is assumed. For some other distributions, further parameters, such as skewness (third central moment) or peakedness (fourth central moment), may be necessary. The justification for this assumption of normality is based on precedent. The normal distribution can be viewed as a mathematical result empirically shown to be valid for a large number of different experimental situations. It is still only an assumption, and it is well worthwhile to make a visual

Table B.1. Commonly used population parameters and sample statistics

Population parameters	Sample statistics (Estimators of parameters)
μ_x (mean—first moment)	$\bar{X} = \frac{1}{n} \sum_{i=1}^{n} x_i$
σ_x^2 (variance—second central moment)	$s_x^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2$
σ_x (standard deviation of x about μ_x)	$s_x = \sqrt{s_x^2}$
$\sigma_{\bar{x}}$ (standard error of the mean, or standard deviation of the average)	$s_{\bar{x}} = \frac{1}{\sqrt{n}} s_x$
$\sigma_{xy} = \sigma_{yx}$ (covariance)	$s_{xy} = s_{yx} = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})$
$\frac{\sigma}{\mu}$ (100) (coefficient of variation, or relative standard deviation, expressed in percent)	$v_x = \frac{s_x}{\bar{x}}$ (100)

examination of the data for any marked departures from normality. There are some simple procedures to do this. They include construction of a histogram or graphical test using probability paper. The discussion of random uncertainties that follows assumes that a normal distribution is justifiable. It can be shown that this subsequent treatment is not absolutely dependent on a normal population distribution. The Central Limit Theorem states this, provided the departures are not too great, and further predicts that the convolution or folding together of nonnormal distributions tends to form normal distributions. The probabilities for some typical intervals in the normal distribution are provided in Table B.2. As stated before, an analysis of the observed values will be used to estimate μ and σ^2.

Table B.2. Probabilities for same typical intervals in normal distribution

Interval $(\mu - \zeta\sigma_x)$ to $(\mu - \zeta\sigma_x)$ (ζ)	Percentage of the population within this interval (%)
0.6745	50
1.000	68.269
1.960	95
2.000	95.450
2.576	99
3.000	99.73

Sample Mean and Standard Deviation

For n measurements of x, the best estimate of the parameter μ is obtained from the mean ($\bar{x}$) of the sample, and the best estimate of σ^2 from the variance (s_x^2), where

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \rightarrow \mu \ . \tag{1}$$

and

$$s_x^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_1 - \bar{x})^2 \rightarrow \sigma_x^2 \ . \tag{2}$$

The sample standard deviation is the square root of the variance, or the quantity s_x. It refers to the standard deviation computed from a sample of measurements.

Standard Error of the Mean

Any mean $\bar{x}$ is determined from a finite number of measurements. If the determination is repeated, one can obtain a series of slightly different $\bar{x}$ values. According to the Central Limit Theorem, for large n, the distribution of these $\bar{x}$ values will be close to normal for any distribution of x that has at least two finite moments. Thus, a standard deviation of this distribution could be obtained from repeated determinations of $\bar{x}$. It may, however, also be estimated from just the measurements used in a single determination of x. This estimate of the precision on the mean is termed the standard error of the mean ($s_{\bar{x}}^2$), which is given by

$$s_{\bar{x}}^2 = \frac{s_x^2}{n} = \frac{1}{n(n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2 \ . \tag{3}$$

The quantity $s_{\bar{x}}^2$ is termed the variance of the mean. The standard error of the mean ($s_{\bar{x}}$) must not be confused with the sample standard deviation (s_x). The standard deviation s_x is only dependent on the measurement precision, whereas $s_{\bar{x}}$ depends on both the precision and the number of observations.

Appendix C

CHEMICAL RELEASE APPENDIX FOR THE OAK RIDGE RESERVATION FACILITIES 1990 ENVIRONMENTAL REPORT

INTRODUCTION

In addition to indicating the concentrations of various chemicals present in the environment near DOE facilities, in recent years the annual Environmental Reports have contained an estimate of the quantities of certain chemicals being emitted to the environment. This appendix contains an expanded list of chemicals with information regarding the types of releases, the estimated quantities released, the major processes contributing to the releases, and a brief description of the basis of estimates for calendar year (CY) 1990. Radiological chemical releases for CY 1990 are not included in this appendix; they are reported in the applicable chapters of this report.

DISCUSSION

Three categories of chemical releases at each DOE facility are reported in this appendix: (1) SARA 313, (2) Other Large Inventory Chemicals, and (3) Steam Plant Emissions. The SARA 313 chemicals are summarized from the information currently being compiled for the SARA Title III, Section 313 report, required by SARA 1986. This report is submitted on July 1 of each year for the previous calendar year and contains chemicals on the EPA toxic substance list.

Currently, 309 specific chemicals and 20 chemical categories must be reviewed and possibly reported under SARA Section 313. If any of these chemicals were manufactured in excess of 25,000 lb, processed in excess of 25,000 lb, or "otherwise used" in excess of 10,000 lb at a facility during CY 1990, the chemical must be reported. In many instances, the estimate of quantities released was obtained via material balance calculations, monitoring data, or engineering calculations. In some cases, no quantitative monitoring data, or emission factors were readily available, and release estimates were based on "best engineering judgment." Material balance was the principal method used to derive "Quantity released." Information obtained from air permits, rate of operation, quantities used, and known treatment efficiencies were used to estimate quantities released into the environment. Typically, assumptions based on engineering judgment were required to perform the calculations when all variables were not known. Considerable manpower was expended reviewing chemical inventory information and estimating the quantities released to the environment.

Information contained in this appendix may not coincide with the information to be reported for all chemicals under SARA, Title III, Section 313. The SARA 313 report must be submitted to EPA and TDC no later than July 1, 1991. The information for this appendix was generated in the March/April timeframe, and some additional refinements were in progress. It is imperative that the additional 2 months (May-June) be used to ensure compliance under SARA Title III, the Community Right-to-Know law.

The second category of chemicals reported in this appendix is "Other large inventory chemicals." This listing is included to provide the reader with additional chemical information not reportable under SARA 313.

Note that this is not a complete listing of all chemicals that may have been released at a site. This list was developed to better inform the reader of additional chemicals used and released at each site that may be of interest to the general public.

The third category, "Steam plant emissions," is release estimates of certain pollutants from the coal- and/or gas-fired steam plants located at each site.

Chemical release information is included for the Oak Ridge Y-12 Plant(Table C.1), ORNL (Table C.2), and K-25 Site (Table C.3).

DISCLAIMER

Information contained within the 1990 Environmental Report (ER) pertaining to toxic chemical releases at the Y-12 Plant may not coincide with those to be reported under the Superfund Amendments and Reauthorization Act (SARA), Title III, Section 313. The latter report, known as the Toxic Release Inventory (Form R), is to be submitted no later than July 1, 1991, to the Environmental Protection Agency and the Tennessee Department of Health and Environment. These forms furnish information on environmental releases (e.g., air, water, and land) of specific toxic chemicals manufactured, produced, or otherwise used at the Y-12 Plant during calendar year 1990. The data collection and review effort necessary to ensure that the numbers furnished for the ER in April will be identical to those submitted in July on the Toxic Release Inventory Forms cannot be made. It is imperative that the additional 2 months be utilized to ensure compliance under SARA, Title III, the Community Right-to-Know law. Elements requiring additional effort that may result in revision of release numbers are as follows:

- addressing mixtures (i.e., trade name products) containing toxic constituents at 1% or greater and carcinogens at 0.1% or greater;
- tracking bulk acid product distribution systems to identify sources of air emissions for comparison with waste effluents;
- cross-referencing SID numbers and RCRA waste stream numbers with process areas for material balance;
- Confirming operational times of certain processes for use in air emission calculations; and
- cross-checking hazardous material purchases against reported material usage for each process area.

Table C.1. Y-12 Plant chemical release information, 1990

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313		
Acetonitrile	Air: point	2,617/1,190	Solvent usage	Material balance
	Off-site shipment for storage	26,500/12,045	N/A	Shipment records
Chlorine	Air: point	113/51	Stack emissions	Engineering calculations
	Air: fugitive	577/262	Cooling towers	Material balance
	Water: E. Fork	46/21	Cooling towers	Monitoring
Freon 113	Air: point	44,528/20,240	Stack emissions	Material balance
	Air: fugitive	13,103/5,956	Cleaning	Material balance
	Water: E. Fork	74/34	Cleaning	Engineering judgment
	Off-site disposal	6,245/2,839	N/A	Disposal records
	Off-site/sanitary sewer	13/6	Cleaning	Monitoring
Hydrochloric acid	Air: point	18,578/8445	Stack/tank emissions	Engineering judgment
	Air: fugitive	2,039/927	Neutralization	Engineering judgment
	Off-site disposal	50/23	N/A	Disposal records
Hydrogen fluoride	Air: point	3,146/1,430	Stack emissions	Material balance
Methanol	Air: point	43/20	Stack emissions	Engineering judgment
	Air: fugitive	87,880/39,946	Cleaning/cooling	Material balance
	Off-site disposal	365/166	N/A	Disposal records
Methyl chloroform	Air: point	26,678/12,126	Stack emissions	Material balance
	Air: fugitive	3,828/1,740	Cleaning/machine coolant	Engineering calculation
	Water: E. Fork	74/34	Cleaning	Monitoring
	Off-site disposal	5,494/2,497	N/A	Disposal records
	Off-site/sanitary sewer	13/6	Cleaning	Monitoring
Nitric acid	Air: point (emitted as NOx)	57,941/26,337	Cleaning/ processing aid	Material balance
	Off-site disposal	40/18	N/A	Disposal records
Perchloroethylene	Air: point	16,434/7,470	Solvent/degreasing	Material balance
	Water: E. Fork	74/34	Solvent/degreasing	Monitoring
	Off-site disposal	5,220/2,372	N/A	Disposal records
	Off-site/sanitary sewer	21/10	Cleaning	Monitoring

Table C.1 (continued)

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313 (continued)		
Sulfuric acid	Air: point	23/7	Processing aid	Engineering judgment
	Air: fugitive	9/3	Film processing	Engineering judgment
	Off-site disposal	352/160	N/A	Disposal records
	Water: E. Fork	168/76	Spill	Engineering judgment
		Other large inventory chemicals		
Freon 11	Air: fugitive	30,600/13,909	Refrigeration systems	Material balance
Freon 12	Air: fugitive	4,615/2,098	Refrigeration systems	Material balance
Freon 22	Air: fugitive	3,880/1,763	Refrigeration systems	Material balance
Freon 114	Air: fugitive	6,450/2,932	Refrigeration systems	Material balance
Mercury	Water: E. Fork	20/9	Stormwater runoff	Monitoring
	Land	945/430	Spill	Monitoring
	Off-site/sanitary sewer	11/5	Cleaning	Monitoring
	Off-site disposal	1,762/801	N/A	Disposal records
	Off-site shipment for storage	428/195	N/A	Shipment records
Acetic acid	Air: point	65/30	Tank emissions	Engineering calculations
		Steam plant emissions		
Sulfur dioxide	Air: point	1,136,000/516,364	Stack emissions	Emission factors
Nitrogen oxide	Air: point	1,617,500/735,227	Stack emissions	Emission factors
Carbon monoxide	Air: point	87,700/39,864	Stack emissions	Emission factors
Particulates	Air: point	5,800/2,636	Stack emissions	Emission factors

Table C.2. ORNL Plant chemical release information, 1990

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313 chemicals		
Nitric Acid	Air: fugitive	145/66	Tank emissions	Engineering calculations
	Off-site disposal	37/17		Disposal record
Sulfuric acid	Air: fugitive	0/0	Tank emissions	Engineering calculations
	Water: White Oak Creek	0/0 (pH adjusted)	Process water	NPDES records Engineering judgment
	Off-site disposal	175/80		Disposal records
		Other large inventory chemicals		
Ethylene glycol	Land	17,592/7,996	Chilled water system leak/spills	Engineering calculations, spill records
	Water: White Oak Creek	245/113	Leak/spills	Engineering calculations, spill records
	Off-site shipment to Y-12	37,163/16,892	Chilled water system	Operating records
Freon 11	Air: fugitive	2,800/1,273	Refrigeration system	Engineering judgment
Freon 12	Air: fugitive	1,387/630	frigeration system	Operating records
Freon 22	Air: fugitive	2,850/1,295	frigeration system	Operating records
Freon 113	Air: fugitive	2,800/1,273	Refrigeration system Laboratory uses	Inventory records
Freon 502	Air: fugitive	600/273	Large-Scale Climate Simulator	Operating records
Sulfur hexafluoride	Air: fugitive	8,740/3,966	Heavy Ion Accelerator Miscellaneous losses	Operating/inventory records
		Steam plant emissions		
Particulates	Air: Point source	14,052/6,374	Stack emission	Engineering calculations, based on emission factors
SO_X	Air: Point source	1,133,578/514,191	Stack emission	Engineering calculations, based on emission factors
Carbon monoxide	Air: Point source	77,725/35,257	Stack emission	Engineering calculations, based on emission factors
NO_X	Air: Point source	376,953/170,986	Stack emission	Engineering calculations, based on emission factors

Table C.3. K-25 Site chemical release information, 1990

Chemical name	Type of environmental release	Quantity released (lb/kg)	Major release sources	Basis of estimate
		SARA 313		
Chlorine	Air: fugitive emission	29,790/13,541	Water-Treatment	Material balance
	Water: Mitchell Branch	4/2	Spill	Other[a]
	Water: Poplar Creek	90/41	Sanitary Sewer	Monitoring
	Water: Clinch River	255/116	Sanitary Sewer	Monitoring
Sulfuric acid	Air: fugitive emissions	<1/<1	Neutralization/storage	Other[a]
	Land	4/2	Spill	Other[a]
Hydrochloric acid	Air: stack emissions	52/24	Cleaning/pickling/ neutralization	Other[a]
	Air: fugitive emissions	<1/<1	Storage Tank	Other[a]
		Other large inventory chemicals		
Freon 11	Air: fugitive emissions	4,600/2,091	Refrigeration/ systems cooling	Material balance
Freon 12	Air: fugitive emissions	6,265/2,848	Refrigeration/ systems cooling	Material balance
Freon 22	Air: fugitive emissions	5,130/2,332	Refrigeration/ systems cooling	Material balance
Freon 113	Air: fugitive emissions	3,866/1,757	Cleaning	Material balance
		Steam plant emissions		
Particulates	Air: stack emissions	9,451/4,300	Fossil fuels combustion	Emission factors[b]
Sulfur dioxide	Air: stack emissions	1,088/495	Fossil fuels combustion	Emission factors[b]
Nitrogen oxide	Air: stack emissions	57,615/26,189	Fossil fuels combustion	Emission factors[b]
Carbon monoxide	Air: stack emissions	9,632/4,378	Fossil fuels combustion	Emission factors[b]

[a]Based on best engineering judgment.
[b]AP-42, "Compilation of Air Pollutant Emission Factors."

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